SUPREME COURT OF THE UNITED STATES.

OCTOBER TERM, 1916.

No. 3, Original.

THE PEOPLE OF THE STATE OF NEW YORK, COMPLAINANTS,

vs.

STATE OF NEW JERSEY AND PASSAIC VALLEY SEWERAGE COMMISSIONERS, DEFENDANTS.

VOLUME II.

INDEX.

	Original.	Print
Testimony of Kenneth Allen (recalled)	1428	913
Max L. Berrey (recalled)	1463	939
Harry de Berkeley Parsons	1621	1047
Kenneth Allen (recalled)	1659	1072
Charles A. Holden	1679	1087
Robert N. Hoyt	1682	1090
Max L. Berrey (recalled)	1697	1101
Linsly R. Williams	1704	1106
Lawson Purdy	1746	1142
John P. Fox	1750	1144
Floyd J. Metzger	1860	1226
Emil Kuichling	1878	1241
Harrison P. Eddy	2068	1390
Desmond Fitzgerald	2234	1507
Earle B. Phelps	2367	1597
Charles-Edward Amory Winslow	2427	1640
James H. Fuertes	2479	1678

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VOLUME II.

THE PEOPLE OF THE STATE OF NEW YORK, Complainants,
vs.
STATE OF NEW JERSEY and PASSAIC VALLEY SEWERAGE COMMISSIONERS, Defendants.

1428 Supreme Court of the United States, October Term, 1911.

THE PEOPLE OF THE STATE OF NEW YORK, Complainants,
against
STATE OF NEW JERSEY and PASSAIC VALLEY SEWERAGE COMMISSIONERS, Defendants.

CITY HALL, NEW YORK CITY,
January 4th, 1912.—10:30 a. m.

Before James D. Maher, Esq., Commissioner.

Appearances:

Dr. William J. O'Sullivan, Special Counsel for the People of the State of New York.

Adrian Riker, Esq., of Counsel for the Passaic Valley Sewerage Commission.

Joseph Coult, Esq., of Counsel for the Passaic Valley Sewerage Commission.

Robert H. McCarter, Esq., Special Counsel for the State of New Jersey.

Met pursuant to adjournment.

KENNETH ALLEN, a witness called on behalf of complainants, recalled for further examination, testified as follows:

Direct examination (continued) by Mr. O'Sullivan:

Q. Now, taking up the series for 1909, Mr. Allen, these float observations that you have been testifying to, will you proceed and state what observations you made?

A. In taking up the previous float observations, I described the float that we used, made of two tin cans. We found that that was not entirely satisfactory where the traffic was thick, as in
1429 the East River and the Harlem River. We needed something more substantial, heavier and larger, so for these experiments we had a float which was approximately a stick of wood four inches square and five feet long, the lower two feet built up to

a foot square, and the top foot made somewhat larger than the stick. I do not remember the size of that. Made of a stick four inches square and about 5 feet long. At the upper end it was built for 2 feet of a size of 1 foot square, and in the center there was a hole in which an iron rod was inserted, which served as a flag pole, and also as a socket for one or two lanterns to carry at night. On the lower end there were built four plates of plate iron—we used different sizes—varied from about 18 inches by 2 feet to about 20 inches square. These served as vanes to be influenced by the current at that depth below the surface and also to weight the float so that the top would project only an inch or so above the top of the water. The object of these floats was to have them strong enough to resist any ordinary concussion with a boat and to support the lanterns which we wanted to use at night. Taking up these records, the first one is No. 46 of November 8th and 9th, 1909. This was started at 11:03 P. M. opposite Mount St. Vincent, on the east side of the Hudson River.

Mr. Riker: Before the witness uses this blue print, I would like to ask a few questions in regard to it.

Cross-examination by Mr. Riker:

Q. Mr. Allen, what part did you have in the preparation of the print or the positive from which it was taken; I am speaking now of No. 46?

A. Nothing to my recollection, except the supervision of the work, the drafting which I did not do myself.

Mr. Riker: I object to this witness using this blue print for any purpose as it appears he had nothing to do with the making
1430 of it, and it can neither serve as a memoranda made at the time to refresh his memory nor can he prove it as an exhibit.

The Commissioner: Note the objection.

Redirect examination by Mr. O'Sullivan:

Q. When did you first see that, Mr. Allen?
A. This particular print?
Q. Yes.
A. Yesterday.

Mr. O'Sullivan: Read my question.
(Question repeated by the stenographer.)
The Witness: This print?
Mr. O'Sullivan: Strike the question out. Sit down, Mr. Allen.
Mr. Riker: I do not think it ought to be stricken out entirely. He answered, he said yesterday.

Q. Did you see it yesterday?
A. Yes.
Q. Where did you get that print?
A. At the office of the Sewerage Commission.

Q. Did you produce at the hearing yesterday that for the first time?

A. I did.

Q. When did you see the original from which that print was made?

A. At the time it was made, in November, 1909.

Q. Was it made under your supervision?

A. It was.

Q. And were these blue prints made at the instance of the Metropolitan Sewerage Commission, and have they been in their custody all the time until yesterday?

A. Yes.

Q. Will you please explain then what you meant when you answered Mr. Riker that you had nothing to do with it?

A. I did not say that. I said I had not seen this particular print until yesterday.

Q. And where did you see it yesterday?

A. At the offive of the Sewerage Commission.

1431 Q. And it has been in their custody all the time, has it not?

A. Since it was made, yes.

Q. And it was made at their instance, was it not?

A. It was.

Q. Now, what did you have to do with regard to the original from which that blue print was made for the Metropolitan Sewerage Commission?

A. I supervised the drafting, the plotting.

Q. The mechanical work done by the draftsmen, was it done under your supervision?

A. Yes.

Q. Have you got your original minutes or notes in court here today?

A. Of the observations?

Q. Yes.

A. No, I have not.

Q. You did not bring them down today?

A. No, I have not.

Q. You had them here yesterday?

A. No.

Q. What minutes were you using yesterday?

A. The blue prints and the description in the report.

Q. Made by whom?

A. By myself.

Q. They were your copy of the report?

A. Yes.

Q. Have you got it in court now?

A. Yes, not with regard to these. There never was a report on this later series.

Q. What book were you consulting yesterday when you were testifying, Mr. Allen?

A. That was a book containing copies of reports that I made to

the Sewerage Commission, and included reports on these float experiments prior to 1909.

Q. And on some of the series you submitted reports?

A. Yes.

Q. Which are already marked in evidence?

A. Yes.

Q. Now, the particular chart that you now have before you, did you submit a report on that?

A. No.

Q. Describe what you did with Float No. 46, what observations you made?

1432 Mr. McCarter: The question is objected to on the same ground.

The Commissioner: Note the objection.

Mr. Riker: It is objected to on the ground that the paper before the witness is not the memoranda in any sense of the word and it is not an exhibit.

The Commissioner: Note the objection of counsel for defendants.

Q. Describe what you did in the way of observations with Float No. 46?

A. Float No. 46 was put in opposite Mount St. Vincent on the east side of the Hudson River November 8th, at 11.03 P. M. and went down the Hudson to opposite 67th Street, Manhattan, at 3.45 A. M. at slack tide. Then it moved westerly across the river and at 5.10 A. M. went northward to 110th Street. At 8.25 A. M. it went westerly for 15 minutes and then southerly to 10.40 A. M. There it grounded, it was obstructed, and we took it up and it was replaced again at 10.45 A. M. opposite 71st Street, and it went southerly to 12.05 P. M. when it grounded on the west shore—it ran against a wharf or something of that sort and was replaced opposite there in the center of the river at 12.07 P .M. opposite 21st Street, and was taken out at 1.40 P. M.—or it was lost by a tug, at 1.40 P. M. nearly opposite the Battery.

Q. Did you cause the observations to be plotted upon a map or chart which you have described now relative to float No. 46?

A. I did.

Q. Have you got that chart or map?

A. I have a print of it.

Mr. O'Sullivan: I offer the course taken by float No. 46 on November 8 and 9th 1909, as described by this witness, I offer in evidence the map or chart, and ask that it be marked Complainants' Exhibit No 73.

Recross-examination by Mr. Riker:

Q. You have testified that this float did certain things.

1433 Were you there when these observations were made?

A. A part of the time.

Q. How much of the time?

A. I saw them start the experiments in the evening, at night, and then went back. Only a short part of the time.

Mr. Riker: I object to the offer on the ground that it does not contain anything that this witness knows anything about, except the immediate start of the float.

The Commissioner: Note the objection of counsel for defendants. Receiven and marked Complainants' Exhibit No. 73.

Marked Complainants' Exhibit No. 73.

Redirect examination by Mr. O'Sullivan:

Q. Who was in charge of the observations from the time that you started in?

A. This work was done by relays. We started by having three men, they relayed each other during the twenty-four hours—we started having two men, and then we had three men and after that two men, and now the three that did this—I cannot tell, without looking at the original notes, and I have not those here. I can find that though if you want it.

Q. What next did you do relative to float observations?

A. Float No. 47 was set in November 9th, and taken up November 12th, 1909.

Recross-examination by Mr. Riker:

Q. Now, before this witness uses his memoranda, I would like to ask some questions. Did you prepare the original from which the blue print was made?

A. No, I did not.

Q. Did you make the observations which are supposed to be recorded on that blue print?

A. I think none of them.

Mr. Riker: I object to the use of this paper, as it is not either a memorandum by him or containing anything that he did himself.

1434 The Commissioner: Note the objection of counsel for defendants.

The Witness: Well——

Redirect examination by Mr. O'Sullivan:

Q. The next one?

A. The float was set out at 9.52 P. M. opposite Mount St. Vincent on November 9th, just before the beginning of the ebb current. It went northward a very short distance and then southerly until 2 A. M. when it was lost opposite 155th Street. Another float was set in its place at 6.45 A. M.—the float was found again and reset at 6.45 A. M. opposite west 137th Street, and went northerly to just north of Fort Washington Point, at 8.15 it grounded and was reset on the west side of the river at 8.25 A. M. It went northerly to Inwood across the river, down on the easterly side, grounded at 10.58 A. M. and was reset near the middle of the river at 8.25 A. M. It then went southerly and at 12.05 P. M. grounded on the west shore,

and was reset in the middle and then went southerly and grounded at the west shore at 2.10 P. M. It was taken up and reset in the middle; at 2.15 it went southerly to opposite Pier 15 Manhattan, at 4.15 P. M. Then the current reversed and it went northerly to opposite West 72nd Street at 9.45 P. M. and southerly to opposite St. George at 4 A. M. then northerly opposite 72nd Street at 9.45 A. M. —I beg pardon, that last was wrong—it went northerly to the Manhattan Bridge, where the current reversed at 8.53 P. M. Thence southerly to opposite Norton's Point at 2.20 A. M. thence northerly to Gowanus Bay at 9.10 A. M. thence southerly to south of Coney Island Point at 2.20 A. M. November 12th when it was taken up.

Q. Were you in charge of all these fl-at observations?

A. I was.

A. Did you cause the course of Float No. 47 to be plotted on a map or chart?

A. I did.

Q. Have you got that map or chart here?

1435 A. I have the print.

Mr. O'Sullivan: I offer the map or chart showing the course as described by this witness, taken by float No. 47 on November 9th to November 12th, 1909. I offer that in evidence, and ask that it be marked Complainants' Exhibit No. 74.

Recross-examination by Mr. Riker:

Q. Mr. Allen, did not you tell me that you had nothing to do with the matters supposed to be recorded here personally?

A. I had supervision of them.

Q. What do you mean by having supervision of them?

A. The draftsmen doing the work and the observers, they did their work under my direction.

Q. Well, the observers did the work under your direction, what do you mean by that?

A. I gave them instructions for doing it.

Q. Were you present?

A. No, probably not. I occasionally made trips to inspect the work. I was not on the boat much of the time.

Q. And when certain supposed data were furnished you, you turned them over to the draftsmen, did you not?

A. Yes.

Q. That is all you did?

A. Excepting to see that he was doing the work properly.

Mr. Riker: I object to the offer on the ground that it has not been proved by this witness to contain any fact.

The Commissioner: Note the objection of counsel for defendants.

Received and marked Complainants' Exhibit No. 74.

Marked Complainants' Exhibt No. 74.

Q. What next observations did you make relative to the floats?

A. Float No. 48 on November 15th, 1909. Float No. 48 was put in on the west channel of the east——

Mr. Riker: One moment. You are using a paper to
1436 testify from, are you, Mr. Allen?
The Witness: Yes.

Recross-examination by Mr. Riker:

Q. Does that contain any work that you did yourself?
A. That depends a little on just what you mean. It represents my work to a certain extent, but the drafting on the paper I did not do myself, no.
Q. Not on the original paper?
A. Not that I remember, no.

Mr. Riker: I object to the use of the paper on the ground that it is not a memoranda to refresh the witness' memory.
The Commissioner: Note the objection.

Redirect examination by Mr. O'Sullivan:

Q. Go on.
A. The float was put in the west channel of the East River November 15th, 1909, opposite East 56th Street at 11 A. M. It went northerly nearly to the Queensboro Bridge, to about 11:30 then it went southerly to Buttermilk Channel opposite the south end of Governor's Island, at 4.35 P. M. when it went northerly almost to the Brooklyn Bridge on the Brooklyn side, and was taken up at 7 P. M.
Q. Did you cause the Float No. 48 that you have just described to be plotted on a map or chart?
A. I did.
Q. Under your directions?
A. I did.

Mr. O'Sullivan: I offer the map or chart showing the course taken by Float No. 48 on November 15th, 1909, as described by this witness. I offer it in evidence and ask that it be marked Complainants' Exhibit No. 75.

Recross-examination by Mr. Riker:

Q. Were you present during the observations to which you have testified?
A. I was not.
Q. How do you know that what you have stated as fact is true?
A. Only from my knowledge of the work of the men who
1437 did the work itself. That work was checked up from time to time.
Q. I am speaking now of this particular exhibit?
A. Yes.
Mr. O'Sullivan: Have you finished your answer?
The Witness: Not quite. The work was checked up from time to time by visits to the boat to see whether it was being carried on as

desired and in the same way the drafting was inspected to see whether it was being done properly.

Q. I am confining my question to this particular chart, Mr. Allen?

A. Yes.

Q. How do you know that anything that you have stated to be a fact actually occurred?

A. In no other way than by my knowledge of the men that did the work.

Mr. Riker: I object to the offer on the ground that it is admittedly a representation of hearsay on the part of this witness.

The Commissioner: Note the objection of counsel for defendants.

Mr. O'Sullivan: Were these men working under your directions?

The Witness: They were.

Mr. O'Sullivan: And the draftsmen prepared that chart under your direction?

The Witness: Yes.

The Commissioner: Note the objection. Received and marked Complainants' Exhibit No. 75.

Marked Complainants' Exhibit No. 75.

Redirect examination By Mr. O'Sullivan:

Q. What next observation did you make relative to the floats?

A. Float No. 49, November 16th and 17th, 1909. This was set out at the mouth of the East River at 1.54 P. M.

Mr. Riker: The witness appearing to use a memorandum I would like to ask in regard to this memorandum.

1438 Recross-examination by Mr. Riker:

Q. Did you make the observations supposed to be recorded on the paper, from which you are reading?

A. No.

Q. Did you make the original from which the blue print was taken?

A. I did not.

Mr. Riker: I object to the use of it on the ground that it is not a memorandum made by the witness that can be used to refresh his memory.

By Mr. O'Sullivan:

Q. Were the observations made by men under your direction?

A. They were.

Q. And was the chart or map that you have before you prepared under your direction, by draftsmen in the employ of the Metropolitan Sewerage Commission?

A. It was.

Mr. O'Sullivan: We will have those men and draftsmen later, Mr. Riker.

Mr. Riker: Well, I suppose so, Doctor, but not being here, for fear that you might on some account not have them here, I have to put these objections on the record.

The Witness: It went southerly to a little south of Bay Ridge. At 6.25 P. M. it turned northerly and grounded at Owl's Head at 7.55 P. M. It was reset and went westerly and then northerly until 12.20 A. M. when it reversed in Buttermilk Channel, opposite the north end of Governor's Island. It then went southerly down the center of the Bay until 5.22 A. M. when it was opposite Bay Ridge, and it went northerly up the East River to the east of the south end of Blackwell's Island at 12.50 P. M. then southerly grounding at 2 P. M. north of the Williamsburg Bridge. It was reset at 11.15 A. M. in the middle of the river, went southerly through the Buttermilk Channel to a little north of Red Hook when it was taken up at 3.35 P. M. on the 17th of November.

Q. Did you cause the course that you have described as
1439 taken by Float No. 49 to be plotted on a map or chart?

A. I did.

Q. Under your direction?

A. Yes.

Q. And by a draftsman employed by the Metropolitan Sewerage Commission?

A. Yes.

Mr. O'Sullivan: I offer the chart or map showing the course described by this witness as Float No. 49 on November 16th and 17th, 1909, I offer it in evidence and ask that it be marked Complainants' Exhibit No. 76.

Recross-examination By Mr. Riker:

Q. Mr. Allen, does that paper print contain any fact within your own personal knowledge, so far as the supposed course of Float No. 49 is concerned?

A. I am not sure that I saw the float at all during its progress.

Q. And when you say the float took certain directions, at certain times, all you mean is that you were told it did and you believed it?

A. I was told it was also in the notes.

Q. You were told verbally or by writing and you believed it?

A. Yes.

Mr. Riker: I object to the offer on the ground that it contains nothing but hearsay, so far as this witness is concerned.

Redirect examination by Mr. O'Sullivan:

Q. The observations were made by men employed by the Metropolitan Sewerage Commission and under your directions?

A. Yes.

Q. And the chart or map was prepared under your direction by a draftsman employed by the Metropolitan Sewerage Commission?

A. Yes.

Q. And you were directed to make these float observations by the Metropolitan Sewerage Commission?
A. Yes.

Recross-examination by Mr. Riker:

Q. Mr. Allen, when you say they were made by persons in
1440 the employ of the commission, how do you know they were so made?
A. Well, I made enough visits to the work to satisfy myself that the floats were put in and followed. I had conversations with different members of the party and crews of the boat, which I visited, that certain distances had been covered.
Q. With reference to this particular exhibit, how do you know that the observations which are supposed to be recorded in that blue print or exhibit were made at all?
A. Only by my confidence in the integrity of the men that made it, that did the work.
Q. Mr. Allen, you are swearing to this thing. You are swearing that they were made. I want to know what you base your evidence on?
A. On my knowledge of the men that did the work, and my occasional inspections of the work.

Mr. Riker: I object to the exhibit, I renew my objection.

Redirect-examination by Mr. O'Sullivan:

Q. Did these men report to you daily on the observations made?
A. They were not able to do that always. Sometimes they were out several days, but whenever they came in they reported.
Q. They reported each detail of the observations?
A. Yes.
Q. And you were the proper man to make the report to, were you?
A. Yes.
Q. You were in charge of the observations?
A. Yes.

The Commissioner: Note the objection. Received and marked Complainants' Exhibit No. 76.

Marked Complainants' Exhibit No. 76.

Q. What next float observation was made, Mr. Allen?
A. Float No. 53, November 22nd and 23rd, 1909.
1441 Mr. Riker: Is the paper you are testifying to of the same character and was it made in the same way and does it contain the same class of data as the last one testified to?
The Witness: In character, yes.

Mr. Riker: I object to the use of the memorandum to refresh the witness' memory, on the ground that it does not appear to have been made by him or to contain any observations or fact within his own knowledge.
The Commissioner: Note the objection.

Q. Mr. Riker asked you if that chart contains the same data as the preceding chart?

A. It does not.

Q. You may proceed.

A. The float was started at slack water, November 22nd, at 11.40 A. M. on the west side of the East River, just below the mouth of Newtown Creek. It went northerly to 34th Street where it grounded at 12.25 P. M. It was reset a little farther out. It went northerly to the west of the south end of Blackwell's Island and grounded again and was reset on the easterly side of the channel and went northerly off to College Point. At 5.20 P. M. it reversed direction and at 7.40 P. M. it was taken out south of Riker's Island and reset east of the north end of Riker's Island at 7.55 P. M. From there it went down north to North Brother Island, through Hell Gate and grounded west of Hell Gate on the west shore at 12.27 A. M. It was reset in the center of the channel and went northerly along the west shore of Ward's Island and was picked up at 1.35 A. M. November 23rd, just northwest of Ward's Island.

Q. Did you cause to be plotted on a map or chart under your direction the course that you have described as taken by Float No. 53?

A. I did.

Mr. O'Sullivan: I offer the course as described by this witness taken by Float No. 53 on November 22nd and 23rd, 1909, in evidence and ask that it be marked Complainants' Exhibit No. 77.

Recross-examination by Mr. Riker:

Q. Mr. Allen, I think you testified in answer to me that
1442 this paper which has been offered was prepared and contained data of a similar character under similar conditions as the preceding one, that is what you said, was it not?

A. Yes, that is right.

Q. And you did not prepare the original yourself from which this blue print was taken?

A. No.

Q. And you did not make the observations which are supposed to be set forth in it?

A. No, I did not.

Q. To be recorded on it?

A. No. I did not.

Mr. Riker: I object to the offer on the ground that it is admittedly without any probative value and contains no fact that is within this witness' knowledge, and the paper was not prepared by the witness himself, and does not contain any fact of which the witness has any personal knowledge.

The Commissioner: Note the objection of Counsel for Defendants. Received and marked Complainants' Exhibit No. 77.

Marked Complainants' Exhibit No. 77.

Redirect examination by Mr. O'Sullivan:

Q. Were the float observations relative to No. 53 made by men under your direction?
A. They were.
Q. Did those men report to you?
A. Yes.
Q. Was that chart that has just been offered in evidence and marked Complainants' Exhibit No. 77 prepared by a draftsman in the employ of the Metropolitan Sewerage Commission under your direction?
A. It was.
Q. What was your next float observation, Mr. Allen?
A. No. 55, November 29th, and 30th, 1909. This was set in the East River, opposite East 34th Street in the middle of the stream at 10.55 A. M.
Mr. Riker: Pardon me, Mr. Allen. I observe you are using a paper to testify from. What is the paper that you are testifying from?
1443 The Witness: This is a record of the movement of the float.

Recross-examination by Mr. Riker:

Q. Was this prepared in the same manner as the last exhibit?
A. It was.
Q. And were the observations made by you personally?
A. They were not.
Q. Supposed to be recorded hereon?
A. No.
Q. When did you first see this paper you are testifying from?
A. This print?
Q. Yes.
A. Yesterday.

Mr. Riker: I object to the witness using this paper in evidence in giving his evidence as it does not appear to be a memorandum which is competent to refresh his memory, and contains no fact within his own knowledge. It was not made by him and he never saw it until yesterday.
The Commissioner: Note the objection of counsel for defendants.

Redirect-examination by Mr. O'Sullivan:

Q. Where did you receive that chart you are now using?
A. From the Metropolitan Sewerage Commission.
Q. The original of that chart was prepared by whom—under whose direction?
A. Under my direction.
Q. When?
A. Very soon after the observations were made. I cannot say the date when that was made.

Q. Describe the course taken by that float, Mr. Allen?

A. The float was put in the middle of the East River opposite 34th Street. It went southerly to the Lower Bay, south of Swinburne Island. At 7.40 P. M. it went northerly to point east of Hoffman Island, at 11.30 P. M. and then southerly, southeasterly down the Ambrose Channel, to a point southeast of Romer Light at 3.43 A. M. and then westerly about 6 miles and at 10.20 A. M. it was taken up and replaced about a mile and a half west of Romer Light at 11.06 A. M. It then went southeasterly
1444 and southerly past the Scotland Lightship and was taken up at 6.30 P. M. several miles southeast of Sandy Hook.

Q. Did you cause the course that you have described as taken by Float No. 55 to be plotted on a map or chart?

A. I did.

Mr. O'Sullivan: I offer the map or chart showing the course as described by this witness taken by Float No. 55 on November 29th and 30th, 1909, I offer it in evidence and ask that it be marked Complainants' Exhibit No. 78.

Mr. Riker: I object to the offer on the same grounds as the use of the paper was objected to.

The Commissioner: Note the objection.

Received and marked Complainants' Exhibit No. 78.

Marked Complainants' Exhibit No. 78.

Q. When did you make the next float observation?

A. Float 56. December 1st to 4th, 1909.

Mr. Riker: You are about to use a paper to testify from?

The Witness: Yes.

Recross-examination by Mr. Riker:

Q. When did you see that paper for the first time?

A. I saw this print yesterday for the first time.

Q. And the original from which it was made, when did you see that first?

A. When it was made about the first of the year, 1910.

Q. Have you compared the two?

A. I have not.

Q. And you were asked when next you made a float observation, did you make the float observations which are supposed to be recorded on this paper?

A. Not personally.

Mr. Riker: I object to the use of the paper by this witness for any purpose as it appears not to have been made by him, and it does not purport to contain any observations or facts within his own knowledge.

The Commissioner: Note the objection of counsel for
1445 defendants.

Redirect examination by Mr. O'Sullivan:

Q. Were those float observations made by men under your direction?

A. They were.

Q. Did those men report to you?

A. Yes.

Q. Did you occasionally visit the scene of the observations?

A. Yes.

Q. You may proceed.

A. The float was set in December 1st, 1909, just east of Passaic Light, Newark Bay. It went southerly past Shooter's Island, and then easterly down the Kill von Kull. I will not be able to pick out all these lines here. I will have to simplify this description a little. To a point about opposite the west New Brighton, and then back to about the point of starting for two tides, two tidal periods. In the third tidal period it went up stream to just below the Central Railroad of New Jersey Bridge in Newark Bay and then went down to the mouth of the Kill von Kull. It then went up the stream once and on the next ebb tide rounded St. George and followed the shore of Staten Island to a point near Stapleton where it was taken up at 6.50 A. M. December 3rd. Then it was reset at 7.05 A. M. and went southerly until 9.55 A. M. opposite Gravesend Bay. It then went northerly right into Gravesend Bay until 11.05 A. M. and then reversed and rounded Norton's Point, and went southerly until southeasterly of Coney Island, midway between the Ambrose Channel and the shore when it was taken up at 6.25 P. M. and replaced at 7.12 P. M. about a mile to the south. It then continued southerly until 9.30 P. M. when it was about east of Sandy Hook, and then went northerly about one mile and a half northwest of the point, where it was taken out at 6.25 P. M. And at 1.30 A. M. the current reversed and it went southeasterly to a point about 8 miles away, when it was taken out at 6.55 A. M., December 4th.

1146 Q. How many tidal cycles did your observations of Float No. 56 cover?

A. 6½ complete tidal cycles.

Q. Did you cause the course that you have just described as taken by Float No. 56 to be plotted on a map or chart?

A. I did.

Q. And was the plotting done by a draftsman in the employ of the Metropolitan Sewerage Commission under your direction?

A. It was.

Mr. O'Sullivan: I offer the course as described by this witness, the map or chart showing this course taken by Float No. 56 on December 1st to 4th, 1909 in evidence and ask that it be marked Complainants' Exhibit No. 79.

Mr. Riker: I object to the offer on the ground that the paper has not been proved or authenticated as required by law, and it admittedly contains no fact within the knowledge of this witness and does not contain any facts proved in the cause.

The Commission: Note the objection.
Received and marked Complainants' Exhibit No. 79.
Marked Complainants' Exhibit No. 79.

Q. Were these obeservatins conducted under your direction?
A. They were.
Q. And were the reported observations reported to you?
A. They were.
Q. And did you cause the course of the observations to be plotted upon Complainants' Exhibit No. 79?
A. I did.
Q. When did you next make any float observations, Mr. Allen?
A. No. 57 December 6th to 8th, 1909. The float was started at 2.15 P. M. December 6th at the Brooklyn Bridge, on the east side of the East River. It went northerly——

Mr. Riker: Excuse me, please, the witness is using a paper
1447 now, I think.

The Witness: Yes.

Recross-examination by Mr. Riker:

Q. The paper that you have before you, Mr. Allen, when did you see that first?
A. Yesterday.
Q. And the original from which it was taken, have you ever seen it?
A. Yes.
Q. When?
A. Soon after the observations were made, about two years ago.
Q. What part did you have in the making of the original?
A. Supervising the draftsman.
Q. Did you compare the blue print with the original as it was when you originally saw it?
A. I did not.
Q. Do you know of your own knowledge whether the blue print is a correct representation of the original as you saw it after it was prepared under your supervision?
A. I do not.
Q. Does the paper before you contain a record of any float observations made by yourself?
A. Not that I know of.

Mr. Riker: I object to the use of the paper by this witness on the ground that it is not a memorandum made by this witness at the time, or containing any fact within his own knowledge.

The Commissioner: Note the objection of Counsel for defendants.

The Witness: Float No. 57 was started December 6th at 2.15 P. M. on the east side of the East River at the Brooklyn Bridge. It went northerly, grounded at South Second Street and it was reset at 2.50 P. M. near the middle. It went northerly to Huron Street, and grounded and was reset at 3.20 P. M. in the middle. It went northerly up the west Channel and around Blackwell's Is-

land, the current turning at 5.20 P. M. It grounded at 6
1448 P. M. east of the south end of Blackwell's Island and it was reset at 6.05 P. M. It went southerly through the East Channel down the river to Governor's Island, where it grounded twice on the west side and was finally reset at 10.30 P. M. It went southerly to opposite Stapleton and at 6.30 A. M. it went northeasterly into Gowanus Bay. At 6.25 A. M. it reversed and went southwesterly grounding on the Staten Island shore, north of the Narrows, just north of the Narrows at 11.45 A. M. It was reset and went southerly until 1.05 P. M. when it was a short distance east of a point midway between Hoffman and Swinburne Island. It then west northerly and again grounded on the east shore of Staten Island near the Narrows and was reset at 5.15 P. M. in the Narrows, and went northerly to just east of St. George Ferry. At 7.30 P. M. December 7th it reversed and went southerly and grounded at Coney Island Point at 11.35 P. M. It was then reset a short distance west of the point and went southerly and reversed at 3 A. M. and went northerly to the middle of Gravesend Bay. At 4.30 A. M. it again went southerly, grounded on Norton's Point and was reset at 5.50 and then went southerly and then easterly opposite the shore of Coney Island, until a short distance west of Rockaway Point at 10.45 It was reset at 11.10 A. M. and then went southeasterly to a point about a mile and a half south of Coney Island Point, and was taken up at 1.40 P. M. December 8th.

Q. Were these observations made by relays of men under your direction?

A. They were.

Q. Continuing day and night?

A. Yes.

Q. Did they report these observations to you?

A. They did.

Q. Did you cause the observations as you described the course taken by this Float No. 57, to be plotted on a chart or map?

A. I did.

1449 Q. Was this chart or map made under your direction by draftsmen in the employ of the Metropolitan Sewerage Commission?

A. It was.

Mr. O'Sullivan: I offer the chart or map showing the course, on which is plotted the course as described by this witness, taken by Float No. 57 on December 6th, to 8, 1909, in evidence and ask that it be marked Complainants' Exhibit No. 80.

Mr. Riker: The offer is objected to on the same grounds as the last offer, the offer of the last exhibit.

The Commissioner: Note the objection of counsel for defendants. Received and marked Complainants' Exhibit No. 80.

Marked Complainants' Exhibit No. 80.

Q. When next did you make a float observation?

A. No. 58, December 9th and 10th, 1909.

Q. What was the date?

A. December 9th and 10th, 1909. This float was set out at 11.35 A. M. December 9th, a short distance southeast of Robbins Reef Light.

Recross-examination by Mr. Riker:

Q. Excuse me, Mr. Allen, you are using a paper again?
A. Yes.
Q. Of the same character as the last one?
A. Yes.
Q. And prepared in the same manner as the last one?
A. Yes.
Q. From any facts within your own personal knowledge?
A. None, except as I have stated.
Q. And when did you see this paper first?
A. Yesterday.
Q. And the original?
A. Soon after it was made.
Q. Have you compared it with the original?
A. I have not.

Mr. Riker: I object to the use of the paper by this witness on the same grounds as the last paper which was offered as an exhibit.

The Commisioner: Note the objection of counsel for defendants.

1450 Redirect examination by Mr. O'Sullivan:

Q. Proceed.

A. It was set at 11.35 A. M. December 9th, a short distance southeast of Robbins Reef. It went southerly at 1 P. M. when it grounded, just north of Fort Wadsworth, and was reset in the middle of the Narrows at 1.20 P. M. It then went southeasterly until 2.40 P. M. and then northerly grounding near Fort Hamilton when it was reset again near the middle of the Narrows at 4.40 P. M. and went easterly toward the shore and then skirted the eastern shore of the Narrows, grounding at Bay Ridge at 6.35 P. M. It was reset at 6.45 P. M. in the middle of the stream, went northerly until 7.35 P. M. when it was a short distance south of the starting point. It then went easterly and southerly through the Narrows and at 1.30 A. M. was east of a point between West Bank Light and Romer Light. It then went northeasterly, nearly to Fort Hamilton, when the tide changed at 6 A. M. It then went toward Coney Island Point and was picked up at 9.55 A. M. It was reset at 10.15 northwest of Coney Island Point. It then went southerly until 11 A. M. when it was taken out a short distance southwest of Coney Island Point.

Q. Were the observations that you have described made by relays of men during December 9th and 10th, 1909?
A. They were.
Q. Did they report their observations to you?
A. They did.
Q. Did you cause those observations to be plotted on a map or chart by draftsmen employed by the Metropolitan Sewerage Commission?
A. Yes.

Mr. O'Sullivan: I offer the map or chart on which is plotted the

course taken by Float No. 58 on December 9th and 10th, 1909, in evidence and ask that it be marked Complainants Exhibit No. 81.

Mr. Riker: The offer is objected to on the same ground as
1451 the last offer, the offer of the last exhibit.

The Commissioner: Note the objection. Received and marked Complainants' Exhibit No. 81.

Marked Complainants' Exhibit No. 81.

Q. When next did you make a float observation?

A. December 14th and 15th, 1909, Float No. 60.

Recross-examination by Mr. Riker:

Q. Mr. Allen, you have got before you again a paper which you are going to testify from, are you?

A. Yes.

Q. And you were asked when did you make these observations. Were the observations that are supposed to be recorded here your own personal work?

A. They were not.

Q. You did not make them, did you?

A. No.

Q. When did you first see the paper you are about to testify from?

A. Yesterday.

Q. And the original from which the blue print was made, when did you see that?

A. About two years ago.

Q. Have you compared the two?

A. I have not.

Q. Have you seen the original between the time you name and the present time?

A. Yes.

Q. When?

A. I cannot say when, but I see them every few days.

Q. Can you say that the blue print is a correct reproduction of any paper that you have ever seen before?

A. Not from comparison.

Q. Did you make any part of the observations which are supposed to be recorded here?

A. Not that I remember.

Mr. Riker: I object to the use of the paper on the same grounds as objection was made to the use of the last paper by the witness.

The Commissioner: Note the objection.

Redirect examination by Mr. O'Sullivan:

Q. Were these observations made under your direction?

1452 A. They were.

Q. By relays of men working day and night during the 14th and 15th of December, 1909?

A. Yes.

Q. Did you cause these observations to be plotted on a map or chart?

A. I did.

Q. After they had reported to you?

A. I did.

Q. Did you see the original tracing or plotting shortly after the observations were made?

A. Yes.

Q. Of which this is a copy that you are now using?

A. Yes.

Q. You may proceed?

A. This float was set southwest of Throggs Neck in the upper East River, December 14th, 1909, at 2.30 P. M. at the time of the change of current. It went first southerly toward Whitestone and then easterly towards Willett's Point, and then northerly. Then again easterly until off Elm Point, at 6.45 P. M. At 6.55 P. M. it was reset near the middle of the stream and passed easterly across the mouth of Manhasset Bay to the shore where it was taken up and reset at 11.35 P. M. It went southeasterly and grounded on the shore and was reset at 12.30 A. M. near the middle of the mouth of Manhasset Bay. From then it went northerly, grounded on Barker Point. It was reset in the middle of the Bay at 3.30 A. M. and went northeasterly and grounded on Barker Point at 4.35 A. M. It was reset at 4.40 A. M. between Barket Point and Hart Island. It then went northeasterly past Sands Point, and at a point north of Sands Point, its motion was a spiral from about 8.30 A. M. until about 1.20 P. M. It then started off in a northeasterly direction and was taken up a short distance southwest of Mattinicock Point at 6.45 P. M. December 15th.

Q. Did those relays of men who made these observations report to you?

A. They did.

1453 Q. Did you cause the observations to be plotted on a map or chart indicating the course taken by the float, during December 14th and 15th?

A. I did.

Mr. O'Sullivan: I offer the map or chart showing the course taken by Float No. 60 on December 14th and 15th, 1909, as described by this witness in evidence and ask that it be marked Complainants' Exhibit No. 82.

Mr. Riker: The offer is objected to on the same grounds and for the same reasons as were offered on the last exhibit.

The Commissioner: Note the objection.

Received and marked Complainants' Exhibit No. 82.

Marker Complainants' Exhibit No. 82.

Q. When next did you make or cause to be made float observations?

A. December 16th, 17th and 18th, 1909.

Recross-examination by Mr. Riker:

Q. Mr. Allen, your are using a paper again?

A. Yes.

Q. And is this paper of the same character and compared in the same way as the last paper that you used that was subsequently offered as an exhibit?

A. It is.

Q. Does it contain any original observations made by you or in your presence?

A. Not that I remember.

Q. And have you compared it with the original of which you supposed it to be a blue print?

A. I have not.

Mr. Riker: I object to the use of it on the grounds that were urged against the use of the last paper used by this witness.

The Commissioner: Note the objection.

Recross-examination by Mr. O'Sullivan:

Q. What number is that float, Mr. Allen?

A. No. 61. This float was started in the Arthur Kill December 16th, at 11.55 A. M. off Elizabethport. It went northerly, a short distance north of the Baltimore & Ohio Railroad Bridge, and thence southerly through two cycles of tide, each time going to a point between Tuffts Point and Smoking Point on the Arthur
1454 Kill. On returning the second time it passed the starting point and went to the mouth of Newark Bay, northwest of Shooter's Island. It then went a short distance southwesterly, and easterly and south of the Island and then returned, rounding the light house off the mouth of the Arthur Kill. It was then taken up and reset just west of Shooter's Island and went northerly to near the Central Railroad of New Jersey Bridge across the Newark Bay. It was reset then a short distance to the south and went southerly and easterly to the Kill von Kull and grounded at 2 A. M. December 18th, on the north shore of Staten Island, just east of Port Richmond.

Q. How many tidal cycles did the observations that you have just described relative to Float No. 61 occupy?

A. Three and one half complete cycles.

Q. Approximately will do, Mr. Allen?

A. I will make sure of that.

(Witness examines data.)

Three and one half.

Q. Were these observations made by relays of men during December 16th, 17th and 18th in the year 1909?

A. They were.

Q. Did those men report to you?

A. They did.

Q. Did you cause the reported facts to be plotted on any map or

chart by a draftsman employed by the Metropolitan Sewerage Commission?

A. I did.

Q. Did you see the original after plotting?

A. Yes.

Mr. O'Sullivan: I offer the map or chart showing the course testified to by this witness as having been taken by Float No. 61, during the 16th, to the 18th of December, 1909, in evidence, and ask that it be marked Complainants' Exhibit No. 83.

Mr. Riker: The same objection to this as to the last offer.

The Commissioner: Note the objection of counsel for the defendants.

1455 Received and marked Complainants' Exhibit No. 83.
Marked Complainants' Exhibit No. 83.

Q. When were the next observations made on float experiments?

A. Float No. 62, December 20th and 21st, 1909.

Recross-examination by Mr. Riker:

Q. Is this paper you are about to testify from of the same character and prepared in the same way as the last paper that you used?

A. It is.

Q. And the blue print itself you saw for the first time yesterday?

A. I did.

Q. When did you see the original?

A. I do not remember the day, but I see the originals every few days.

Q. Did you compare this paper with the original?

A. I did not.

Q. Did the originals contain any record of any original observations made by you or when you were present?

A. Not that I know of.

Mr. Riker: I object to the use of this paper on the same grounds as the last used by this witness.

The Commissioner: Note the objection of counsel for defendants.

Redirect examination by Mr. O'Sullivan:

Q. Proceed.

A. This float was started December 20th at 1.15 P. M. a little south of the point midway between Willett's Point and Throggs Neck. It went towards Willett's Point. It was then taken up and reset a short distance to the north and went towards City Island until 2 A. M. and then the current reversed and it grounded off Throggs Neck and was taken up at 3.10 A. M. and reset off Throggs Neck. From there it went westerly grounding near Whitestone Point. It was reset near the middle of the stream, and then went westerly and then in various directions until 10.20 A. M. without going but a short

distance and then the current carried it towards Willett's Point where it was taken up.

1456 Q. It had been in the water how many tidal cycles?

A. Two tidal cycles.

Q. Were relays of men observing that float during that entire time?

A. They were.

Q. Did they report to you the result of their observations?

A. They did.

Q. Did you cause a draftsman employed by the Metropolitan Sewerage Commission to plot of any map or chart the course taken by Float No. 62?

A. I did.

Mr. O'Sullivan: I offer the map or chart showing the course taken by Float No. 62 on December 20th and 21st, 1909, as described by this witness, I offer it in evidence and ask that it be marked Complainants' Exhibit No. 84.

Mr. Riker: The same objections are offered to this offer as to the last.

The Commissioner: Note the objection.

Received and marked Complainants' Exhibit No. 84.

Complainants' Exhibit No. 84.

Marked Complainants' Exhibit No. 84.

Q. The next one?

A. Float No. 63, December 21st, 1909.

Recross-examination by Mr. Riker:

Q. This paper, Mr. Allen, is it of the same character as the last one?

A. It is.

Q. Prepared in the same way?

A. Yes.

Q. Does it contain any original observations made by you?

A. Not that I remember.

Q. And the blue print is of the same character, made, so far as you know, at the same time as the last?

A. Yes.

Q. And have you compared it with the original tracing?

A. I have not.

Mr. Riker: The use of the paper is objected to on the same grounds as I objected to the last paper used by the witness.

The Commissioner: Note the objection.

Redirect examination by Mr. O'Sullivan:

1457 Q. The time?

A. It started at 4.10 December 21st off Clasons Point. It went easterly for a short distance and at 4.35 the current reversed and it passed down north of Riker's Island through Hell Gate to the

east of the north end of Blackwell's Island, when the current reversed again, and it grounded near the east shore at 11.15 A. M. and was reset at 12.05 P. M. opposite the north end of Blackwell's Island. From there it went back through Hell Gate, went ashore at College Point and was reset at 2.48 P. M. and continued easterly and grounded again east of College Point. It was reset off Claisons Point at 3.25 P. M. and continued easterly and was taken up at 4.15 P. M. off Whitestone Point.

Q. Did you cause the course taken by Float No. 63 to be plotted on a map or chart?

A. I did.

Mr. O'Sullivan: I offer the map or chart showing the course just described by this witness as having been taken by Float No. 63 on December 21st, 1909, in evidence and ask that it be marked Complainants' Exhibit No. 85.

Mr. Riker: The offer is objected to on the same grounds as the last offer.

The Commissioner: Note the objection of counsel for defendants.

Received and marked Complainants' Exhibit No. 85.

Marked Complainants' Exhibit No. 85.

Q. When next did you direct float observations?

A. December 22nd and 23rd, 1909, float No. 64.

Recross-examination by Mr. Riker:

Q. You are about to testify from a paper again, Mr. Allen?

A. I am.

Q. That was prepared in the same general way?

A. Yes.

Q. As the last?

A. Yes.

Q. And does it contain any record of any original observations by you?

A. Not that I remember.

Q. Or those made under your direction when you were
1458 present, I mean?

A. Not that I remember.

Q. When did you first see this paper?

A. Yesterday.

Q. And the original, when did you see that first?

A. Soon after the observations were made.

Q. Can you say that this is a correct representation of the original that you saw after it was made?

A. I have never compared them.

Mr. Riker: I object to the use of this paper on the same ground as to the use of the last paper.

Redirect examination by Mr. O'Sullivan:

Q. Proceed?

A. It was set out at 7.20 A. M. December 22nd, 1909, in the

middle of the stream off Whitestone Point. It went towards Riker's Island, the current reversing at 11.15 A. M. when a short distance from the Island. At 11.10 A. M. it went ashore at College Point and was reset on the opposite side of the stream off Clasons Point. It then went easterly until 1.45 P. M. when it was taken up and reset in the middle of the stream at 1.55 P. M. and continued until off Throggs Neck at 2.55 P. M., December 22nd. The course then was in all directions in the vicinity of Throggs Neck and Willett's Point.

Q. Describe in what figures, circles or spirals?

A. It is very irregular, in all directions at different stages of the tide until 11.40 P. M. It then passed south of Throggs Neck until off the middle of Eastchester Bay, and at 2.30 A. M., December 23rd, it was taken up and reset a short distance to the west. It was reset at 2.45 P. M. It then went easterly to Hewlett Point, when it grounded and was taken up and reset at 3.45. It returned and grounded on the same point and was reset between Hewlett Point and City Island at 4.35. It went southerly and was taken up at 5.55 and reset at 6.15 off City Island. It went southerly and was taken up again at 7 o'clock and set in at 7.20 off City Island. It then went towards Throggs Neck again and remained in
1459 that vicinity until 1.40 P. M. December 23rd, when it was finally reset east of Throggs Neck and went easterly to between Hart Island and Hewlett Point, and then south grounding on Hewlett Point at 3.40 P. M., December 23rd.

Q. Under your direction was the course taken by Float No. 64 plotted on a map or chart?

A. It was.

Mr. O'Sullivan: I offer the chart or map showing the course taken by Float No. 64 as described by this witness on December 22nd and 23rd, 1909, and which is shown by this map or chart, I offer the chart or map in evidence and ask that it be marked Complainants' Exhibit No. 86.

Mr. Riker: The offer is objected to on the same grounds and for the same reason as the last paper marked as an exhibit.

The Commissioner: Note the objection.

Received and marked Complainants' Exhibit No. 86.

Marked Complainants' Exhibit No. 86.

Q. Proceed?

A. Float No. 65 December 27th to December 30th. This one is so complicated that I am afraid I cannot read it very well. I want to know if I can read it from the description in the report?

Q. Yes.

Mr. O'Sullivan: That is an illustration of the report?

Mr. Riker: You are not going to use this chart for the purpose of this testimony?

Mr. O'Sullivan: We have not come to it yet, Mr. Riker.

Q. I ask you for your observations of Float No. 65?

A. Float No. 65 was set out in midstream off College Point.

Mr. Riker: One moment, what is it you are reading from now?
The Witness: This is the report made by the Metropolitan Sewerage Commission on the work of the float observations.

Recross-examination by Mr. Riker:

1460 Q. And the paper that you are reading from, what did you have to do with that?
A. I wrote out the description from the map.
Q. And the map that you wrote it from, where is that?
A. At the office of the Metropolitan Sewerage Commission.
Q. Have you compared this description with that map?
A. I made the description from the map.
Q. I ask you whether you have compared the description as you are about to read it?
A. In the book?
Q. Yes.
A. With the map?
Q. Yes.
A. No, not since it was printed that I remember.
Mr. O'Sullivan: Did you since it was printed?
The Witness: I think not.

Mr. Riker: I object to this witness using this printed document, on the ground that it does not appear to be a memorandum of anything even of things reported to this witness.
The Witness: Can I use this to refresh my memory?
Mr. O'Sullivan: Have you ever read the printed matter before you, before now?
The Witness: Yes.

Redirect examination by Mr. O'Sullivan:

Q. When?
A. I could not say when.
Q. Have you ever seen a like volume to that?
A. Yes.
Q. Have you ever read the description given on that volume of this float?
A. Yes.
Q. Did it correspond with your report, did you in any way make an effort to see that it corresponded?
A. Not since it was printed that I remember.

Mr. O'Sullivan: I will have to withdraw it, Mr. Allen. It is clearly worthless.
The Witness: Supposing I make it from the map?
Mr. O'Sullivan: Make it from the map, yes.

1461 Recross-examination by Mr. Riker:

Q. Now, you are about to use the blue print, are you, Mr. Allen?
A. Yes.
Q. When did you see that blue print for the first time?

A. Yesterday.
Q. And what did you have to do with the preparation of the original from which this blue print was taken?
A. I had supervision of the drafting.
Q. When was that drafting done?
A. Soon after the observations were made.
Q. Have you compared this blue print with the original drafting?
A. I have not.
Q. Did you make any of the observations which are supposed to be recorded on this blue print, or the original from which it was taken?
A. Not that I remember.
Q. How do you know whether the course of this float which is supposed to be delineated on this chart is correctly indicated on the chart?
A. Only by occasional tests of the integrity of the men, and the work they were doing.
Q. Any test on this particular part of the work that you remember?
A. I do not remember.

Mr. Riker: I object to the use of this blue print on the same grounds that were urged to the use of the last.
The Commissioner: Note the objection.

Redirect examination by Mr. O'Sullivan:

Q. Proceed?
A. This float was started December 27th, at 10 A. M. off College Point, and went southerly and then westerly down the East River and between that and the time it was taken out it oscillated back and forth between Ferry Point and the Brooklyn Bridge. It was taken out December 30th at 4.30 P. M. near the shore of the Bronx, opposite North Brother Island.
Q. How many tidal cycles had that float No. 65 been in
1462 the water?
A. Six and one half—six and one quarter, or six and one half.
Q. Was it under observation during all of that time by relays of men in the employ of the Metropolitan Sewerage Commission?
A. It was.
Q. Did they make their reports to you of their observations?
A. They did.
Q. Did you cause these observations to be plotted on a map or chart by a draftsman employed by the Metropolitan Sewerage Commission?
A. I did.

Mr. O'Sullivan: I offer the map or chart showing the direction taken by Float No. 65 on December 27th, to December 30th, both inclusive, in the year 1909, I offer it in evidence and ask that it be marked Complainants' Exhibit No. 87.

Mr. Riker: The offer is objected to on the same grounds as the last one.

The Commissioner: Note the objection of counsel for defendants. Received and marked Complainants' Exhibit No. 87.

Marked Complainants' Exhibit No. 87.

At Mr. O'Sullivan's request an adjournment was taken at this hour to enable him to procure original data which the witness had failed to produce.

At 12.30 adjourned for noon recess until 2 P. M.

1463 CITY HALL, NEW YORK, January 4th, 1912.

Afternoon Session, 2 p. m.

KENNETH ALLEN a witness called on behalf of Complainants, recalled for further examination, testified as follows:

Direct examination (continued) by Mr. O'Sullivan:

Q. Mr. Allen, you were requested at the time of recess to produce the original tracings from which these blue prints were made; have you done so?

A. I have.

Q. I now direct your attention to Complainants' Exhibit No. 32, being a chart showing the float observations for float No. 1?

A. I have here the original tracings, and the chart. The tracing of Float No. 1 and Exhibit No. 32, and find that they correspond in all particulars.

Mr. McCarter: Just one moment. We are inclined to waive proof that the blue prints are copies of the tracings. I do not think there is anything in that. That does not admit that the tracings are competent evidence, but we will not ask you to prove that the blue print is a copy of the tracing. That would be simply ridiculous. We are pretty bad, but we are not as bad as that.

Mr. O'Sullivan: I withdraw this witness just a moment. Mr. Berrey, will you take the stand, please?

MAX L. BERREY a witness called on behalf of the Complainants, recalled for further examination, testified as follows:

Direct examination by Mr. O'Sullivan:

Q. You have testified in this suit on a previous occasion, have you not, Mr. Berrey?

A. Yes, sir.

Q. What is your vocation or business?

A. Topographical draftsman.

Q. And are you connected with any commission now?

A. I am connected with the Metropolitan Sewerage Commission of New York as Topographical draftsman.

1464 Q. And how long have you been connected with the Metropolitan Sewerage Commission as draftsman?

A. Since February of 1909.

Q. During the months of August, September, October and November and December of 1909, did you receive direction from any one to make tracings of float courses?

A. Yes, sir.

Q. From whom?

A. I took directions from Mr. Allen.

Q. Mr. Kenneth Allen?

A. Mr. Kenneth Allen.

Q. Who was just on the stand before you took the stand now?

A. Yes, sir.

Q. Have you produced those tracings in court?

A. Yes sir.

Q. Who made those tracings; who drew them, who was the draftsman?

A. Part of them were made by myself, and some were made by Mr. John Fox. I believe Mr. Kenneth Allen plotted some; I am not positive, but I believe so. It is my remembrance.

Q. Where did you get the tracings that you produced here in court?

A. From the office of the Metropolitan Sewerage Commission.

Q. Are they part of their records?

A. They are.

Q. What do you know in relation to those blue prints, as to when they were made?

A. The blue prints were made during the month of December, 1911.

Q. This past December?

A. Yes.

Q. Were they made from these tracings?

A. Made from the original tracings.

Q. Have you produced them here?

A. Yes, sir.

Mr. O'Sullivan: Your witness.

Cross-examination by Mr. McCarter:

Q. Such of the tracings as you made, are you able to identify?

A. I am.

Q. By any signature or initial?

A. I cannot say my signature appears.

1465 Q. What method would you pursue; would you take the field books that were handed to you as containing the observations by certain gentlemen who had observed floats that had been put in the water at different places and from those entries in books make the tracings?

A. I would.

Q. You did not have anything to do with the observations that were contained in the field books, did you?

A. No, sir, nothing whatever.

Q. Take the field books, as they were handed to you, you took a tracing and traced out the different ones as you were directed to do?

A. Yes, sir.

Q. For instance, taking a field book (counsel examines field book) What method would you pursue? You did not have in this field book a sketch or map; would you hypothecate lines between the two given places where the notation appeared?

Mr. Sullivan: You better, Mr. McCarter, let him describe what he did.

Mr. McCarter: All right, describe what you did.

The Witness: I took the field books, the field notes that were turned over to me. I looked them over to see what part of the harbor they covered, the float had covered. I took a coast and geodetic survey chart—the best, the only authority there is for this sort of work that I know of—took a piece of tracing paper, laid it over the geodetic survey chart, then laid my locations, piers, streets, and buoys, lighthouses, prominent points of the kind, which were noted in the books by the observer who made the record. In that way I could plot the different points at which time and distance from certain points they were taken, observed and those points could be plotted on these tracings, and the different points, lines connecting the different points.

Q. Interpolated?

A. Yes, to the best of my knowledge.

Q. For instance, having taken the geodetic survey and plotted on one of those tracing papers, the location, then you undertook
1466 to locate upon that document the points that were not in the field books, as having been observed?

A. Yes, sir.

Q. And you then connected in the course of the float, the given points by hypothesis or interpolation?

A. As a rule. Sometimes if there was any great length of time between the two observations, I might ask the observer about where he went.

Q. And you would take what he said if that was a sufficient length of time?

A. Ordinarily the observations were taken quite close together, within a few minutes, so there would be a very short distance between the points of observation.

Q. Do you know how many of these observations there were?

A. Do you mean on one test or through the whole series?

Q. Through the whole series?

A. I cannot say that now, exactly.

A. Several.

Q. And they would note the result of their tests in these, what I call field books, that lie before you here?

A. Yes, sir.

Q. You did not make any observations yourself, I suppose?

A. None at all.

Q. This geodetic survey, is it a federal or a state document?

A. That is a Federal Bureau.

Q. And then the blue prints of course are the regular blue prints of the tracings, so that if the tracing is right, the blue print necessarily is right, it is not altered in any way at all?

A. That must be correct.

Q. Well, now, taking the blue print, which—we will take Exhibit No. 32 for instance, as a specimen. This has on it this phrase: "Total distance covered 4.5 miles in one hour and 55 minutes. Average velocity 2.3 miles per hour." Did you make those computations?

A. I did not.

Q. Who did that, if you know?

A. I have no personal knowledge, but I think Mr. Fox plotted that particular float record.

Q. That is not one of your records?

A. I had nothing to do with that record.

1467 Q. Can you pick out one that is; I simply want to find out how you did it personally. This is Complainants' Exhibit number 73. Did you make any computations on this that you plotted. This does not seem to have any computations, corresponding, for instance, to the phrase "Total distance covered 4.5 miles in 1 hour and 55 minutes; average velocity 2.3 miles per hour."

A. No, I did not do that.

Q. Do you know anything about the method pursued by the other plotters, to tell us how a computation of that kind, which I have just read from Exhibit No. 32 was made. Was that computed by the plotters or by the observer?

A. That was computed by the plotter.

Q. In other words after he had plotted on his map the distance covered by the float in the manner you have indicated, he would then scale off the distance and designate below the result, is that right?

A. I believe that is the method, yes.

Q. And do you know how he got at the velocity, or the average velocity?

A. The average velocity is obtained by the total distance covered, and you have the total time it took to cover that distance.

Q. Then you would add up the times covered, included in the field book in the particular observation and he would measure the distance and plot it in the manner you have indicated, and by a simple method ascertain the average velocity?

A. I believe that is the method.

Cross-examination by Mr. Riker:

Q. Did you make any allowance for the time these floats were stranded or out of water?

A. Do you mean does that appear?

Q. Do you know whether there were allowances made?

A. In figuring the velocity?
Q. Yes.
A. I cannot say.

By Mr. McCarter:

Q. Who is the J. P. F. whose initials appear on so many
1468 of these different exhibits?
A. John P. Fox.
Q. Is he still in the employ of the commission?
A. Not at this time.
Q. But any blue print or tracing containing those initials indicates that Mr. Fox was the man who prepared the tracing?
A. That is my knowledge of the point, yes.

Mr. McCarter: That is all.
Mr. O'Sullivan: That is all, Mr. Berrey. Counsel for Complainants desires to direct the attention of Counsel for the defense to the fact that these tracings are here now and that he has no power of retaining them, in case any comparisons are deemed necessary. Take the stand, Mr. Allen.

KENNETH ALLEN a witness called on behalf of Complainants, recalled for further examination, testified as follows:

Direct examination (continued) by Mr. O'Sullivan:

Q. Mr. Allen, you were requested to produce the original field note books submitted to you by the observers; have you done so?
A. I have.
Q. And you have them now in court?
A. Yes.
Q. How often were those reports made to you by the men who were making the observations?
A. As a rule they would turn the book in as soon as they came in from the field, turn the book in at the office, and then take another book in the field while the first book was left in the office for plotting the float records.
Q. So that they used books alternately in that way?
A. Yes, most of the time. The first period of time when making the shore records, they might use one book several days in succession. They might use it a week, and then turn it in.
Q. Some of the float numbers as you testified to them, Mr. Allen, I noted were not alluded to. Take Float No. 20. What became of that?
A. Float No. 20 I believe is in the same sheet as Float No. 19.
1469 Q. What have you in your hand, now, Mr. Allen?
A. I have the float record of numbers 19 and 20.
Mr. O'Sullivan: Complainants' Exhibit No. 55?
The Witness: Yes.
Q. Is the course of Float No. 20 shown on Complainants' Exhibit No. 55?

A. It is.
Q. Describe it.

Mr. McCarter: The same objection.
Mr. Riker: The same objection. The facts ought to appear.
The Commissioner: Note the objections.

A. It was put in the upper East River at 1.20 o'clock a little north of Stepping Stone Light. For the date, I will have to refer to the note book. It went in a southerly direction, past the Lighthouse, and it was taken up 7 minutes past 2. No observation in between the two points. I will look up that date.
Q. Yes.

Mr. McCarter: Please note on the record that Defendants' Counsel observes that the witness is proposing to use the note books that were made by the observers, and not by him, as a means of enabling him to testify. We respectfully contend that he has no right to use them, no more than counsel or anybody else would have, and evidence based on such use is not legal evidence.
The Commissioner: Note the objection.
Mr. Riker: I want to interpose the further suggestion that if he uses them, that the books must be put in evidence.
Mr. O'Sullivan: Complainants' Counsel desires to state in answer to that that as these are public records he has no power to do other than have the witness stimulate his memory from them, and if deemed necessary later, I will have copies of them made. I am not permitted to put them in evidence.

1470 Q. These note books were handed to you by the man who made the observations under your direction, that is the fact?
A. Yes.
Q. Consulting the note book in reference to Float No. 20?
A. That was made the same day as No. 19, which was September 3rd, 1908.
Q. And it appears on Complainants' Exhibit No. 55, its course?
A. Right.
Q. Now, Floats Nos. 40 to 45?
A. Floats Nos. 40, 41, 42, 43, 44, 45, were none of them plotted. They were in the water a short time and the courses were so insignificant that it did not seem worth while to plot them.
Q. Now, Floats Nos. 50, 51, 52, 54 and 59?
A. No. 50 was destroyed by a ferry boat after it had been in the water 35 minutes. 51 was lost in a storm and the record was imperfect. 52 was lost after being in the water two and three quarters hours. 54, the work had to be stopped on account of a storm, after being in the water three and one half hours, and No. 59 was stopped for the same reason after two and one half hours' observation. Those records were all so short we considered them as valueless.
Q. That accounts for the whole series reported of float experiments?
A. It does.

Q. What was the specific information sought by those float experiments, conducted by you and under your directions?

A. The most important information that we expected to derive from them was the possible curve that would be taken by the sewage or other material drifting in the harbor. Aside from that it gave an indication of the distance which the tidal flow traversed during a tide. That, of course, only applied to these records that were of sufficient length to cover practically a full tide.

Q. Did some of the float experiments cover more than one tide?

A. Yes.

1471 Q. Did you make any memoranda at the time of these observations or subsequent to them, relative to the information sought and what you deduced from these?

A. Yes, those records were taken and studied individually, and then the result summed up and reported on in a series of reports in 1909. I think there are in 1909 quite a number, but the later series of these longer night experiments which were made in 1910, have not been reported on by me in that form.

Q. What reports did you make on the ones in 1908, taking the close of the year, November?

A. The first one was October 26th, 1908, The second were November 19th, 1908, and February 18th, 1909, and there was also a report made November 19th, 1908, on the general methods employed; what was expected to be obtained through that.

Q. Will you state what you reported on the general methods on the information sought and how these observations satisfied that and to what extent?

Mr. McCarter: I object to it as incompetent, irrelevant and immaterial.

The Commissioner: Note the objection of Counsel for Defendants.

A. The object of the work. A series of float observations was undertaken by the Commission in August for the purpose of securing more definite knowledge regarding the velocity, trend and duration of the currents in the waters of the Metropolitan District. Although much important information of the kind has been already obtained, especially by the Dock Department and by the U. S. Coast & Geodetic Survey, both of whom have gone to considerable trouble in compiling the results of their work for our use, there were certain questions which could not readily be answered without securing additional data. The specific information desired was:

1. The probable course of sewage discharged at any point at any stage of the tide.

1472 2. The mean and maximum velocities that obtain in the various main channels during each tide to arrive at conclusions (*a*) regarding their effect in preventing deposits and (*b*) regarding the amount and directions of the tidal progression of the waters under consideration toward their final disposition in the ocean.

Considerable information regarding the velocities to be expected, especially in the East River, is already available. The velocities of

the Harlem River are, however, an exception, as these appear never to have been accurately observed. But regarding the probable trend of sewage, which is known to confine itself generally to the vicinity of the surface, existing information is not so reliable, and with reference to such an important point as the proposed outlet of the Passaic Valley Sewer is very deficient.

For these reasons a limited number of float observations—sufficient to draw definite although very general conclusions as to the above questions—was deemed most desirable and their cost justified.

2. Methods Employed.

The method usually employed has been to set a float adrift at some known point and follow it with a gasolene launch, taking frequent observations of its location. In particular we have endeavored to secure the record of the float during an entire tide, noting in this way its extreme drift and determining the velocity of the current at frequent intervals, the mean velocity and the trend at each part of the tide. The surface current, which represents more nearly the course that would be followed by sewage, has been considered of most importance, and so the type of float has been selected with this end in view.

The principal types of floats are:

1. Surface floats, such as balls, bottles, cans or blocks of wood.

1473 2. Submerged floats, such as vanes, cans or other large bodies suspended by a cord or wire to a buoy at the surface.

3. Rod floats, such as sticks or tin tubes weighted at lower end so as to float in a vertical position with the upper end projecting above the surface.

The first type is open to the objection that it is influenced by the action of the wind directly and also through the movement of the upper few inches of water and therefore does not always truly indicate the general current of the water.

The second type is serviceable in determining the motion at different depths. It is open to the objection that where the velocity at the lower part or "sinker" is very different from that of the buoy at the surface the one drags the other and the depth of the sinker is less than intended.

The third type is simple in construction and has the advantage of indicating the mean motion of the water between the surface and the lower end. When made of wood, however, in order to prevent possible loss by becoming waterlogged, the top has to project so far as to permit a strong wind to influence its course unduly. It is a type particularly adapted to channels of uniform depth, such as canals, where the float then represents the mean velocity of the entire vertical section in which it is placed.

For our purposes the second type was adopted as permitting observations at varying depths, being least influenced by the wind and being, as designed, quite inexpensive.

As constructed the upper part of "buoy" consisted of a cylin-

drical air-tight tin can, 5⅜″ in diameter by 5″ long, having a short ⅜″ socket on top and an eyelet in the bottom. In the socket an 18″ staff was set carrying a small red flag with a serial number. A #16 gage copper wire attached to the eyelet suspended a
1474 second can at the proper depth—usually 5 feet. This second or "sinker" can was 6″ in diameter by 14″ long, had an eyelet for receiving the wire in the center on top and a ⅞″ nozzle, also in the top, closed by a cork, for receiving ballast. The ballast consisted of water with sufficient sand to nearly submerge the buoy can and so eliminate the influence of the wind. The cost of these double floats per hundred was $25.

This type of float proved very satisfactory in the rivers and Upper Bay. Out of 38 set adrift between August 14 and October 5, 1908, in the Harlem, East and Hudson Rivers, Newtown Creek and the Upper Bay about 14 were lost, most of them by being run down and cut by the propellers of steamers. In general, however, they were not easily destroyed.

The courses of these floats were followed and their paths located by means of a gasolene launch (first the Twilight, 46ft. long x 10 ft. beam, and then the Ethelwin, 30 ft. long by 8 ft. 6 in. Beam) carrying two men besides the observer and with a small boat in tow.

Locations were made by the observer at frequent intervals, depending somewhat on the velocity of the current, by noting the distance from the shore, by noting when in line with or opposite some given pier, street or structure, by bearings to structures whose positions were known with an azimuth compass, or, if distant, by the use of the sextant. For the Harlem and East Rivers locations by streets and distances from shore were most satisfactory. The azimuth compass was most convenient and would have been preferable in most instances except for liability to error due to sluggishness of the needle and to local attraction. For these reasons long sights were entirely unreliable and even with sights of a few hundred feet the error was liable to be too great to be permissible
1475 in so narrow a stream as the Harlem River. The sextant is more precise but owing to the motion of the boat in the prevailing currents the time taken for observation limits its usefulness to the larger areas of the bay.

The path of each float was plotted on a rough tracing of the Coast Survey chart most suitable for the purpose, generally on a scale of $\frac{1}{10000}$ or one of $\frac{1}{15000}$, and the velocity between connecting conservation points calculated by the times of observation and the scaled distances. Where the velocities, as compared with those taken immediately before and after, appeared abnormal, this was generally due to lack of precision in noting the time where the intervals were very short, when an error of one minute in time might result in a very large error in the deduced velocity. In such cases one or more of the intermediate observations have been discarded so as to eliminate errors of this nature and secure a more reliable velocity over a longer distance.

The Harlem and East Rivers offer peculiar difficulties in work

of this kind on account of the enormous traffic carried on by ferries, tugs and barges, canal boats, and, in fact, vessels of every description, so that in the limited water way it was frequently difficult and sometimes impossible to prevent the floats being run down.

3. RELIABILITY OF THE RESULTS.

The narrow width of the Harlem and East Rivers rendered the floats more liable to be blown ashore by the wind and to have their courses affected by bridge piers, docks, etc., and less likely to indicate the true velocity in the axis of the current. I think, however, that we may feel quite safe in relying on the calculated velocities as approximately correct for the conditions of tide and weather when taken, remembering that they are not mean velocities, but more nearly maximum velocities, the center of gravity of the two cans lying about 4 ft. below the surface, and, further, that
1476 while they may represent maximum velocities along the path taken, the length of the path is somewhat greater than the main thread of the current, due to eddies, etc., and as the path itself is not confined to the main thread of the current where the maximum velocity may be expected the resulting velocity is less than would be obtained under those conditions. To sum up, the motion of the float represents the maximum rather than the mean velocity of the stream, but to obtain the true maximum velocity we would have to increase the observed velocity because the path taken does not coincide with the main thread of the current where the greatest velocity occurs, and we would have to decrease the observed velocity because the path taken is devious, due to the effect of piers, eddies, boats, etc., and because it has been observed that the motion of a submerged body in a current of water slightly exceeds that of the water itself.

Whether the first two causes of variation are of importance in any given case can usually be told by reference to the plotted path of the float. The third cause is of too little magnitude to affect any conclusions to be reached on work of this nature. By the observed data taken in connection with an inspection of the plotted courses we should be able to draw general conclusions from float observations of this kind that will be reliable so far as the individual record under consideration is concerned, and it only remains to secure a sufficient number of record- to furnish any information required.

Q. Did you conduct any lines of experiments to determine current velocities in addition to the ones that you reported on?

A. Yes.

Q. When?

A. On January 4th, 1910.

Q. And in the interval had you conducted a series of these float observations?

A. I had, yes.

Q. What conclusions did you reach then as to the experiments you conducted with a view to determining current velocities?

1477 Mr. McCarter: I object to it as incompetent, irrelevant and immaterial.

Mr. Riker: I wish to interpose the objection that without the data upon which the conclusion is founded, proved in a legal way, that his conclusions cannot be introduced in evidence. It is immaterial and irrelevant.

The Commissioner: Note the objections of counsel for defendants.

A. Experiments to determine the velocities of the current to be expected at different stages of the tide were made at the proposed location for the Passaic Valley sewer outlet near Robbins Reef on the Jersey Flats about ⅝ mile south of the P. R. R. Terminal, about ⅝ mile northeast of the P. R. R. Terminal and ¼ mile southeast of Black Tom Island, and at Rockaway Inlet.

Mr. Riker: One moment, I observe the witness reading from some document. I ask the privilege of inquiring what the document is that you are reading from.

Mr. O'Sullivan: Certainly.

The Witness: This is a description of those experiments which was written for the commission at that date mentioned.

Mr. Riker: The Metropolitan Sewerage Commission?

The Witness: The Metropolitan Sewerage Commission.

Recross-examination by Mr. Riker:

Q. And these observations which you stated have been made, did you make them personally?

A. I was present when some of them were made, but not when most of them were made.

Q. And the document which you are reading from is based upon the reports of those that you did not make yourself?

A. Partly, yes.

Q. As well as those that you did make?

A. Yes.

Mr. Riker: I object to the use of it unless the data on which the report was founded has been proved in the cause.

1478 The Commissioner: Note the objection.

Redirect examination by Mr. O'Sullivan:

Q. Mr. Allen, Mr. Riker intimated that the data is not in evidence, the charts or maps that have been marked here as Complainants' Exhibits, do they contain the velocities of the floats?

A. No, not at all.

Q. And these?

A. They do. The velocities were determined by timing the drift of a double can float (as used in the float experiments of 1908) for 100 feet. The velocity so determined was assumed to be that of the water at the depth of the top of the lower can. Determinations of velocity at depths of 20 feet or more are subject to an error in timing

of perhaps 2 or 3 seconds when taken in velocities of over 2 ft. per second, as it was not practicable to start both floats in a vertical, the consequence being that when the top float was set adrift its motion was accelerated by the pull forward of the lower float which had already reached an advanced position. This tendency was in part avoided by allowing the pair of cans to drift a short distance before timing, so that the recorded results are believed to be substantially correct, even at depths of 40 ft.

The direction of the current was observed by sighting to the float with an azimuth compass or by observing some object in line which could be subsequently located on the chart and its bearing determined.

I. At Proposed Outlet Passaic Valley Sewer.

At this location, near Robbins Reef and at the edge of the main channel, the depth was about 50 ft. Two series were taken, each covering practically the 12 lunar hours of the tide—one at or near the time of spring tides and one at or near the time of neap tides—with the intention of showing the differences in velocity to be expected from the phase of the moon. As it was impracticable to take most of the observations on the exact day of springs or neaps the range observed is probably somewhat less than the extreme 1479 due to this cause.

The velocities observed each day have been plotted with reference to the time of H. W. G. I. and the result of each series shown complete in one diagram. Where the same period of the tide has been observed on different days the mean velocity for the observations at this period has been taken.

Velocities were observed near the surface, mid-depth and the bottom—generally 4, 20, and 40 ft. from the surface. From an examination of the resultant diagrams we find that the following velocities may be expected at this location:

Spring Tides.

Depth feet.	Hrs. after H. W. G. I.	Vel. ft. sec.	Hrs. after H. W. G. I.	Vel. ft. sec.	Hrs. after H. W. G. I.	Vel. ft. sec.	Hrs. after H. W. G. I.	Vel. ft. sec.
	Slack high water.		Ebb current.		Slack low water.		Flood current.	
4	2.0	0.6	5.0	3.6	9.5	0.8	12.0x	3.3x
20	2.0	0.4	4.5	3.8	9.5	0.6	0.0x	2.5x
40	2.0	0.6	4 to 6	3.4 to 3.5	9.5	0.4	0.0x	2.0x

Neap Tides.

Depth feet.	Hrs. after H. W. G. I.	Vel. ft. sec.	Hrs. after H. W. G. I.	Vel. ft. sec.	Hrs. after H. W. G. I.	Vel. ft. sec.	Hrs. after H. W. G. I.	Vel. ft. sec.
	Flood current.		Slack high water.		Ebb current.		Slack low water.	
4	1.0	1.3	2.5	0.4	6.0	2.3	9.0	0.4
20	0.5	1.7	3.0	0.3	5.5	2.5	9.0	0.4
40	0.5	1.8	3.0	0.2	6.0	2.3	8.0	0.0

x Interpolated. Record Incomplete.

II. On the Jersey Flats.

The method used here was the same as at the Passaic Valley sewer outlet, the particular object being to determine the velocities near the bottom that may produce erosion.

South of the P. R. R. Terminal these were observed 2 ft. from the surface and about 2 ft. from the bottom, the depth at low water being about 7 ft. The resultant curve was plotted from the
1480 work of several days, irrespective of the phase of the moon.

Mid-depth Velocities in Feet per Second.

Hrs. after H. W. G. I.	Velocity.	Hrs. after H. W. G. I.	Velocity.	Hrs. after H. W. G. I.	Velocity.	Hrs. after H. W. G. I.	Velocity.
Slack L. W.		Flood cur.		Slack H. W.		Ebb cur.	
2.0	.40	4.5	.80	7.0	.15	12.0	1.15

Northeast of the P R. R. Terminal the observations were taken in a similar manner and the depth was about the same, but the work extended over but about six hours.

Mid-depth Velocities in Feet per Second.

Hrs. after H. W. G. I.	Velocity.	Hrs. after H. W. G. I.	Velocity.	Hrs. after H. W. G. I.	Velocity.	Hrs. after H. W. G. I.	Velocity.
Slack L. W.		Flood cur.		Slack H. W.		Ebb cur.	
1½	0.05	..	..	7.0	0.10	11.0	1.10[1]

Off Black Tom Island velocities were observed about 3 ft. below the surface only, the depth at low water being but about 6 ft.

Velocities at a Depth of 3 Ft. in Feet per Second.

Hrs. after H. W. G. I.	Velocity.	Hrs. after H. W. G. I.	Velocity.	Hrs. after H. W. G. I.	Velocity.	Hrs. after H. W. G. I.	Velocity.
Slack H. W.		Ebb cur.		Slack L. W.		Flood cur.	
11.7	0.00	2.50	1.15	7.7	0.00	8.5	0.80

III. At Rockaway Inlet.

Velocities here were taken in the channel between Rockaway Point and the Plum Island with the view of obtaining information regarding the discharge from and into Jamaica Bay. Assuming that the average of the velocities at one fifth and four fifths depth would give the mean velocity in that vertical, observations were made approximately at these depths. Generally about 9 feet and 36 feet with the following results:

Mean Velocity in Channel in Feet per Second.

Hrs. after H. W. G. I.	Veloc.	Hrs. after H. W. G. I.	Vel.	Hrs. after H. W. G. I.	Vel.	Hrs. after H. W. G. I.	Vel.
Slack H. W.		Ebb cur.		Slack H. W.		Flood cur.	
0.5	0.0	3.0	3.4	7.0	0.0	9.0	2.1

[1] Record incomplete. The maximum velocity probably occurred later than this.

1481 From the plotted velocity curves the mean velocity was found to be 2.22 feet seconds during the ebb, and 1.42 feet From soundings made by the United States Engineer Corps, in this case to be but 0.8, that in the vertical taken, the mean cross sectional velocities for ebb and flood were found 1.78 and 1.14 feet seconds respectively.

From soundings made by the United States Engineer Corps, in 1908, the area of the cross section at low water, was calculated to be 75,240 square feet. The range of the tide being 4.8 feet. The area at mean tide was estimated at 88,800 square feet. This is necessarily a very rough approximation, as elevations on the low lying shore are not known.

With these factors the discharge during the ebb was found to be 3,729,000,000 cubic feet, and during the flood 2,136,000,000 cubic feet. Considering the area tributary to Jamaica Bay, it is seen that the net discharge of 1,593,000,000 cubic feet per tide from Jamaica Bay cannot be considered in any way normal, but must be due either to peculiar conditions during the time of observations, to errors in the assumed cross sectional area, at mean tide, or to both these causes.

Q. Mr. Allen, did you compare your results with the report of the Coast Survey of these velocity experiments?

A. The Coast Survey have not data on velocities at those points so no comparison was plotted.

Q. Well, as to the tidal motion?

A. No, I did not know of any data that they have that would be comparable to these.

Q. Did you look at any reports of the Coast Survey at all?

A. Yes, but not with reference to this particular work, experiments at these four points, but with reference to the general subject, yes.

Q. The general subject of what?

A. Tidal phenomena, currents, velocities.

Q. With what results?

1482 Mr. McCarter: I object to that. The best evidence of the observations made by the Geodetic Survey is the survey itself. Comparison can be made by the court if material.

The Commissioner: Note the objection.

The Witness: The only data that we could compare, that I think of were the velocities. The velocities vary very greatly as they will under various conditions. They agree as nearly as can be expected, but there was a great variation at different times in all these streams.

Q. Did you conduct a series of bath house experiments with a view to determining the pollution of the waters?

A. I did, yes. Shall I describe them?

Q. Yes?

A. Those were made with the object of determining whether the water in the bath houses was directly polluted by effluents from sewers. The first one was made by Mr. John P. Fox on August 12th, 1909. Do you want me to read the details or just summarize?

Q. You summarize what the results were.

Mr. McCarter: I object to that on the ground that Mr. Fox should be called and not this witness' statement as to what Mr. Fox did.

The Commissioner: Note the objection.

The Witness: The first experiment was at the 79th Street sewer, South Brooklyn. It was with reference more particularly to the bathing beaches in the vicinity of that sewer. There is no bath house there. It was intended to see if the sewage from the 71st Street sewer polluted the bathing beach just south. It was found that the sewage from the South Brooklyn sewers followed the shore closely with the ebb current. The flow from one sewer mingling with that from the next. I have a summary of the matter here.

Q. How many experiments were conducted?

A. There were thirteen bath houses that were investigated.

1483 Recross-examination by Mr. McCarter:

Q. Did you personally make those investigations?

A. No, I did not.

Q. They were all made by other gentlemen and reported to you and you are giving the results of their reports to you?

A. Yes.

Mr. McCarter: I object as irrelevant, incompetent and immaterial,—I want an objection to each one.

The Commissioner: Note the objection.

Redirect examination by Mr. O'Sullivan:

Q. What were they, Mr. Allen?

A. The first experiment was made August 31st, 1909, a dye being put in at the mouth of the Morris Street sewer during ebb current. The dye consisted of a compound, what we call special scarlet, with a view to seeing whether that polluted the bath house at the Battery. No result was found. September 2nd a similar experiment was made with two pounds of special scarlet.

September 15th the same experiment was tried from the Board Street sewer on the ebb current, two pounds of special scarlet was used with no results.

As to the 51st Street bath house, September 2nd, one half a pound of uranine was placed at the sewer outlet at 50th Street and followed on the flood with no result. On the same day the experiment was repeated and the diffused dye was found in the bath house. August 31st it was tried from the 54th Street sewer on the ebb, one pound of special scarlet with no result.

On the 30th of August, the previous day, it was tried from the 50th Street sewer outlet on the flood and the bath house was found polluted.

September 7th the experiment was repeated with positive results. I was mistaken about those two previous cases where I said it was polluted, it was not, those two previous. It was in this last one only.

The 82nd Street bath house was experimented with on
1484 August 30th from the sewer at 80th Street. One pound of special scarlet being placed at the sewer outlet on the flood without result.

September 4th, the experiment was repeated without result.

September 7th, it was repeated again, and the bathhouse was found polluted, the water in the bath house.

The 97th Street Bathhouse was tried on August 31st one pound of special scarlet was put in at 96th Street with no result.

September 9th it was tried with two pounds of uranine from the 108th Street outlet on the ebb, with no result.

On the 16th it was tried with three pounds of special scarlet from the 96th Street sewer outlet with no result.

On September 21st it was tried again from the same point with three pounds of special scarlet with no result.

On August 31st, near the 137th Street Bath house, an experiment was made taking one pound of special scarlet at the 138th Street sewer outlet and found polluted.

The private bath house at 155th Street was found polluted on August 30th by one pound of special scarlet put in at 158th Street. That finishes those on the North River.

On the East River the bath house at pier 33 was experimented with on August 28th, putting one half a pound of special scarlet in at Jefferson Street on the ebb without result. It was tried again on the same day from Rutger's Slip and found polluted.

The bath house at Collier's Hook was tried August 28th from Collier Street with one pound of special scarlet on the ebb, without result and repeated on the same day without result.

September 2nd, it was tried again without result.

September 2nd, again, and on September 16th again, and each time without result.

The Fifth Street bath house on August 30th was experimented with using two pounds of special scarlet, being put in at the
1485 14th Street sewer on the ebb, the color reaching the bath house, but it being ladies' day we were not able to go inside, so that we could observe it inside.

September 2nd, one pound of special scarlet was put in at the Sixth Street sewer without result.

On the same day two pounds *was* put in at 14th Street without result.

Four pounds were put in on September 14th at 14th Street without result.

September 14th, two pounds were put in at 3rd Street without result.

The 96th Street bath house, on August 31st, a pound of uranine was put in at 95 Street without result.

September 2nd, one pound of special scarlet was put in at 95th Street without result.

September 9th, one pound of uranine was put in off 95th Street without result.

September 18th, four pounds of special scarlet was put in at 95th Street without result.

Brooklyn, 58th Street, August 27th. One pound of special scarlet was put in at 49th Street on the ebb without result.

August 27th, one pound of special scarlet was put in at 64th Street on the flood, it reached the bath house, but being ladies' day was not observed inside.

September 2nd, 64th Street, two pounds of special scarlet were put on the flood tide, without result.

The Dock Street bath house August 28th, 1 pound of special scarlet was put in at Main Street on the ebb.

August 31st one pound of uranine put in at Fulton Street on the flood and the bath house found polluted.

Noble Street, August 31st, 2 pounds of uranine were put in at Huron Street without result.

September 2nd, 2 pounds of uranine were put in at Huron Street without result.

1486 September 11th, 2 pounds of red and one pound of yellow dye were put in at Greenpoint sewer outlet without result.

Q. Mr. Allen, won't you describe what you mean by using this dye and subsequently your expression "found polluted". Did you trace the sewage from the sewer outfall into the bath house, into the bathing establishments?

A. The operation was usually this: the observer took a certain quantity, one pound, or two pounds of the dye, and put it in the water at the mouth of the sewer, usually mixed with water, that is, in a pail, and then dumped it in.

Q. Right at the outfall?

A. Right at the outlet of the sewer. In one or two cases they put it down a water closet or through the manholes, and could see it come out. Then they would go to the bath house and go in and look at the bathing you know and go up on the roof where they could watch it, or on the upper gallery where they could watch and not say anything about their object and wait until they see whether it comes inside or not.

Q. See what comes in?

A. See the uranine or the dye appear in the water that the men were bathing in. If it did appear the assumption was that the sewage also would find its way into the bath house.

Q. And where you saw no results, what does that mean?

A. That means that that experiment failed to give any evidence of pollution in the bath house.

Q. In other words you did not trace it to the bath house?

A. In those cases, no.

Q. It went in other directions?

A. Yes, usually went outside the bath house, toward the channel of the river. I think in something over half the bath houses, we found it.

Q. Found what?

A. That they were found polluted.

Q. I wish you would make that clearer what you mean by found it polluted?

A. In over half the bath houses evidence of pollution
1487 was shown by these experiments, is that clear?

Q. No, it is not, Mr. Allen. Did you by these experiments trace sewage from the outfall into the bath house that it entered?

A. We traced the water, the colored water which of course was mixed with the sewage, coming directly from the sewer outfall into the bath house.

Q. Could the colored water have entered without sewage accompaniment?

A. I do not see how it could.

Q. Is *it* that what you mean?

A. Yes.

Q. What investigations did you make relative to dumping cellar dirt in our harbor waters?

A. I went down to the point where they dumped the cellar dirt, on the harbor inspections, to see how it was conducted, and whether much material floated off on the surface. I found that there was very little that did float on the surface, except sticks—some sticks of wood, and that was so far outside the Narrows, there was no possibility of its coming up into the Upper Bay.

Q. Does that cover the entire investigations that you made?

A. Formerly they have mixed more or less garbage with the cellar dirt, and we wanted to observe it to see whether that was mixed with the cellar dirt and whether that floated off on the surface. They did not seem to include any garbage with the cellar dirt, or it was of an insignificant amount. What was left floating was sticks of wood, and tin cans, nothing of a polluting material.

Q. Did you make any report on drift wood in the harbor?

A. Yes. Looked up the sources of the drift wood and there was a good deal of that floating from time to time in the different streams, and it was difficult to trace to its origin, but apparently a good deal comes from the building operations along the water front, from the dry docks, where they repair the vessels, and more or less comes from the refuse dumped in loading the scows. More
or less of that falls overboard, and is carried up and down
1488 the stream by the tide.

Q. What investigations, if any, did you make, concerning the pollution of New York Harbor from the crews and passengers of vessels using the harbor waters for navigation?

A. I made inquiry as to the number of vessels the steamship lines had and the ferries. The number of passengers and crew carried by boats of different classes, the crews as well and the time that they were likely to remain on the water and made an estimate of the number of people whose adjecta went directly into the harbor. Of course it was very difficult to get a close figure, but it was believed to be sufficiently close to give a fair idea.

Q. Did you make any report of your line of investigation on that topic?

A. Yes, I made a report on that.

Q. When did you make a report?
A. This fall.
Q. Can you give it more accurately?
A. No, I have not it here.
Q. I hand you a memorandum to see if it will refresh your recollection any?
A. This is a copy of that report?
Q. What report?
A. The report that I made on the pollution of New York Harbor.
Q. To whom?
A. To Dr. George A. Soper, the President of the Metropolitan Sewerage Commission of New York on the pollution of New York Harbor by the crews and passengers of vessels. Shall I read that?
Q. Yes; state what you reported as the results of your lines of investigation on that topic?
A. The classification of vessels is based on that of the United States Steamboat Inspection Service.

Mr. McCarter: We object to this as not based on information derived by the witness, it is hearsay and also irrelevant and incompetent.
The Commissioner: Note the objection.

Q. Before making the report, Mr. Allen, will you state how
1489 you collected your data?
A. I saw some of the customs officials with regard to the number of vessels entering the port. I wrote to a number of the steamship companies to get some data from the—got a good deal of data regarding the number of vessels and the crews from the United States Boiler Inspection service, Marine Boiler Inspection.
Q. Is that part of their official duty to collect this data?
A. Yes, they keep track of all the classes of shipping that enter the harbor.
Q. And was it those special matters that you sought these facts in relation to?
A. Yes. I think those points will be made clearer perhaps in reading this.

Mr. McCarter: We renew our objection.
The Commissioner: Note the objection.

The Witness (continuing): The vessels inspected by them at this port include, besides all local steam vessels, all steamers carrying passengers except domestic steamers inspected at other ports and certain gasolene boats, such as those used in oystering. Those inspected in 1910 included—

225 vessels entering and clearing the port for foreign trade—
456 vessels entering and clearing the port for domestic trade—
1,031 vessels that remain in or about New York Harbor

Total.. 1,712

To these there should be added all foreign freight vessels, those carrying passengers that are inspected elsewhere, all sailing vessels and gasolene launches.

The total passengers received and delivered by domestic steamers, including ferries, excursion boats, etc., during 1910 was, according to the U. S. Steamboat Inspection Service.. 167,415,471
The number of immigrants was..... 921,094
and the number of emigrants was..... 320,457

About 1,100 trans-Atlantic and 800 miscellaneous passenger
1490 steamers arrived at the port during the year.

Classified Results.

1. Foreign Ocean Passenger Steamers—Assuming each immigrant is in the harbor 24 hours and each emigrant 1 hour, that an average crew per vessel equals 350 and that they are in port 4 days a month, we have a total of—13,000.

2. Foreign Ocean Freight Steamers—Deducting the foreign passenger from the total foreign steamers, there arrived in the port about 3,384 foreign ocean freight steamers in 1910. Allowing, as an average, 30 men in the crew and a retention of 8 days in port for each vessel, the average number of crew in New York harbor each day was—2,225.

3. Domestic Ocean Passenger Steamers—Information concerning the number of vessels, size of crew and time in port has been obtained from the Panama R. R. Co., Old Dominion S. S. Co., Clyde S. S. Co., Mallory S. S. Co., N. Y. & Porto Rico S. S. Co., Hawaiian S. S. Co., Southern Pacific Co. and Prince Line: about 100 vessels altogether, half of which are inspected in New York. The average number of crew in the harbor is,—1,600.

4. Inland Passenger Steamers—Information of number of boats, size of crew and time in New York harbor has been received from the New England Navigation Co., the Hudson River Day Line and the Hudson Navigation Co. These lines operate 22 boats in summer. Adding 74 other steamers of this class inspected here and assuming an average crew of 30 men, we have a total of about 800.

5. Inland Freight Steamers—There are 109 inspected here. Assuming an average crew of 12 men, the total in the harbor equals 1,300.

6. Ocean Towing Steamers—74 vessels are inspected here. Assuming, from information from the Standard Oil Co., that 15 is an average crew and that each vessel spends 15% of her time in the harbor, the total men in the harbor equals 170.

1491 7. Inland Towing Steamers—There are 505 of these. With an average crew of 7 men and 95% of their time in the harbor, the total number is 3,400.

8. Ocean Pleasure Steamers and Yachts—52 inspected. Assuming 100, with an average crew of 10 men, that spend 10% of their time in the harbor, the total number of men is 100.

9. Inland Pleasure Boats and Miscellaneous—There are 185 inspected. Assuming 400 boats carrying 3 men, the total is 1,200.

10. Seagoing Barges—217 inspected. With a crew of 10 men and 15% of the time in the harbor, the total is 325.

11. Passenger barges—There are 12 inspected. Assuming, in summer, an average crew of 8, the total men in harbor equals 100.

12. Ferries—There are 124 inspected, 10 of these being "municipal". Those not belonging to the city do not, as a rule, have toilets. Assuming 20 boats with an average crew of 15 men, the total is 300.

13. Passengers on Excursion and Ferry Boats—

Total carried on 1910	167,415,471
Assume half of these carried in summer	83,707,735
Average daily in summer	930,080
Deduct for those carried on ferries (677,400, in 1908—4% an. increase), say	730,080
Passengers per day excluding ferries	200,000

Assuming average time on water 1½ hours and that 25% make use of toilet, the total may be taken as 3,000.

The total population delivering excreta directly to the harbor during the summer day may be taken as 27500.

If we assume the insoluble solids given off by 10,000 persons as 556 lbs. (C. M. Tidy), the amount delivered to the harbor per day is 15,290 lbs. or 7.6 tons; and the total solids, estimated at 625 lbs., is 17,188 lbs. or 8.6 tons.

1492 At 4 P. M. adjourned to January 5th, 1912 at 10:30 A. M.

1493 Supreme Court of the United States, October Term, 1911.

THE PEOPLE OF THE STATE OF NEW YORK, Complainants,
against
STATE OF NEW JERSEY and PASSAIC VALLEY SEWERAGE COMMISSIONERS, Defendants.

CITY HALL, NEW YORK CITY,
January 5th, 1912—10:30 A. M.

Before James D. Maher, Esq., Commissioner.

Appearances:

Dr. William J. O'Sullivan, Special Counsel for the People of the State of New York.

Adrian Riker, Esq., of Counsel for the Passaic Valley Sewerage Commission.

Joseph Coult, Esq., of Counsel for the Passaic Valley Sewerage Commission.

Robert H. McCarter, Esq., Special Counsel for the State of New Jersey.

Met pursuant to adjournment.

KENNETH ALLEN, a witness called on behalf of complainants, recalled for further examination, testified as follows:

Direct examination (continued) by Mr. O'Sullivan:

Q. Did you make any investigations, Mr. Allen, which enabled you to report on the financial losses incurred by the pollution in the harbor?

A. I did.

Q. Will you state what investigations you made?

Mr. McCarter: I object to it as immaterial and irrelevant.

The Commissioner: Note the objection of Counsel for Defendants.

A. On December 2nd, I reported on that subject, after investigating the different sources.

Q. What year?

1494 A. December 2nd, 1911. I will read that report.

Mr. Riker: One moment. I desire to object to the proposed testimony on the ground that this witness has not qualified himself as an expert on the question of financial losses.

The Commissioner: Note the objection of counsel for defendants.

A. I beg to report as follows: The Financial Loss Incurred by the Pollution of New York Harbor.

The pollution of the waters of the harbor results in a certain financial loss—direct or indirect. Such loss may be due to the solids which settle at the bottom and require removal, to the polluted water in discoloring, coating, clogging or corroding articles with which it is brought into contact, or to the effect of the odors or gases which escape from the surface of the water.

There are direct losses due to the destruction of marine life. Acids irritate the gills of fish, and, if sufficiently strong, the fish die. An excess of suspended solids or collodial matter interferes with the action of the gills and causes death, and, in general, organic matter may deprive the water of oxygen to such an extent as to extinguish fish life. Aside from the losses caused by the chemical or physical composition of the water, there are further losses due to bacterial contamination of shell-fish. The necessity of abandoning extensive oyster and clam beds in the vicinity of New York has already caused a large, but frequently inevitable, money loss.

a. Losses Due to Deposits.

It is well known that large deposits occur in the slips about New York. It is not so generally known that in the aggregate large quantities of sludge are deposited every year in the Upper and Lower Bays and in all the other large streams or bodies of water known, collectively, as the Harbor of New York. One measure of the extent
1495 of this sedimentation is the amount of dredging done every year, but this is complicated by the fact that much of the

material is digested and passes off in solution or in the form of gas and because in dredging operations, usually carried on to create or maintain a proper depth for navigation, it is not customary to distinguish between material formed by recent deposits and that constituting the original bed of the bay or stream.

The following facts, bearing on this question will give, however, an idea of the extent to which sedimentation takes place.

Dredging Operations by U. S. Government.

(Figures for Fiscal Year Ending June 30.)

Mr. Riker: I will interpose an objection that the operations of the United States Government are immaterial and irrelevant.

The Commissioner: Note the objection.

Q. What year?

A. The years 1907 and 1911. (Continuing.)

	Year ending June 30.	Cu. yds. mud and sand.
Newtown Creek	1907	11,117
	1911	47,332
Wallabout Channel	1911	78,981
Bay Ridge and Red Hook Channels	1907	1,204,011
	1908	1,363,185
	1909	799,727
	1910	1,767,792
	1911	302,714
Ambrose Channel*	1908	5,796,095
	1909	10,786,638
	1910	9,246,401
	1911	5,710,739
Main Ship Channel	1907	93,643
	1908	351,139
	1909	73,681
	1910	459,993
	1911	2,368
Newark Bay and Passaic River	1909	1,158,763
	1910	761,500
	1911	287,502
Channel between New York & New Jersey (includ. N. of Shooters Id., Kill von Kull, etc.)	1909	None
	1910	"
	1911	448,573

*To June 30, 1910 there were dredged for this channel 22,158,192 cu. yds. at a cost of $4,621,135.27 (including the cost of 4 dredges).

1496 Mr. Riker: Pardon me for interrupting you one moment. It has come to my attention that you are reading something. What is it that you are reading?

The Witness: This is a report made by me to the Metropolitan Sewerage Commission.

Cross-examination by Mr. Riker:

Q. When?

A. December 2nd, 1911.

Q. And the facts that you purport to give there are they facts that you yourself ascertained from your own observation?

A. They are not.

Q. Then this is not a memorandum of facts collected by you; made at or about the time when you collected them?

A. They are facts collected by me; not observed by me.

Q. From what sources did you collect them?

A. A number of sources; various sources; such as the Sewer Bureaus in Brooklyn and the sewers that I have mentioned in the report.

Q. Well, were the data collected by you or were they collected by other people?

A. Collected by other people.

Mr. Riker: I object to the use of this paper for any purpose on the ground that so far as it relates to facts they are purely hearsay, and so far as it relates to opinion evidence, that the facts on which it is based are only hearsay, and it is incompetent, irrelevant and immaterial.

Redirect examination by Mr. O'Sullivan:

Q. Mr. Allen, are those facts that you have collected from the Sewer Department in Brooklyn and other sources and are they facts of public record in these departments?

A. Mostly.

Q. Proceed?

A. Dredging rock or sand containing no mud are not included in the above figures.

Regarding the character of the deposits met with in the Lower Bay, Col. S. W. Roessler (Corps of Engineers, U. S. A.) writes (Sept. 27, 1911):

"In the upper three miles of Ambrose Channel, mud was met with in a layer of three to ten feet depth overlying the sand. This

1497 mud on top was brownish in color and very offensive in odor. The mud underneath was black and offensive. In the outer part of Ambrose Channel, mud pockets were formed in which the mud was black and offensive, the odor being apparently due to decaying mussels.

"The mud in Main Ship Canal was generally of a dark grayish black in color and mixed with sand. In odor it was offensive, but

not so much so as the surface mud in the upper end of Ambrose Channel."

Referring to the upper or brownish deposits encountered in dredging Ambrose Channel, Mr. H. N. Babcock, U. S. Assistant Engineer, says that they appeared to be of organic origin, but that the odor was not entirely that of H_2S. These deposits were found, of diminishing thickness, as far south as a little beyond buoy No. 17. They extend perhaps a quarter mile to the east of Ambrose Channel and on the west probably as far as West Bank shoal. The darker underlying deposits were also found west of Sandy Hook. They smelled of H_2S and Mr. Babcock believes may have been brought down by the Raritan River.*

The Department of Docks and Ferries has dredged the following quantities of mud in the past four years:

Year.	1907.	1908.	1909.	1910.
Cu. yds.	386,148	351,794	432,459	499,453

This is in large part material that has settled in the slips. If we take the cost of dredging at 18 cents per cu. yd. the total cost is seen to be about $90,000 for the year 1910.

The Bureau of Sewers, Brooklyn, has done considerable dredging to maintain the proper depth of Newtown Creek, Wallabout Channel and Gowanus Canal. Practically all of this is material that has entered from the sewers of street surfaces, much of it being due to trade wastes. The amounts for several years past in cubic yards, have been, according to Mr. E. J. Fort, Chief Engineer, as follows.**

1498

Year.	Newtown Canal.	Wallabout Canal.	Gowanus Canal.
1908	7,563	.....	12,957
1909	4,415	17,600	10,000
1910	....	5,400	12,345
1911	10,211***	.....	12,500****

The average amount for the first three years is:

Newtown Canal	3,993	cu. yds.
Wallabout Canal	7,670	" "
Gowanus Canal	11,767	" "
Total per annum	23,430	" "

*See also Memo. concerning Deposits in N. Y. Lower Bay, K. A. 8/7/11.

**Letter of Nov. 2, 1911.

***Contract let for 13,225.

****Contract let for 4,200.

The price paid for this dredging is naturally high owing to the congested traffic in these canals, varying from 30 to 60 cents per cu. yd. At 40 cents per cu. yd., the annual cost in the recent past is estimated at $9,400. The expenditure will probably be larger for the current year.

Very little dredging is done by the Bureau along the water front except near the De Graw St. outlet where so much original material has been removed that it is no guide to the sludge deposited.

Mr. A. I. Moulton, General Manager of the New York Dock Co. says:

"Between Catherine Ferry and Red Hook Section * * * there are 16 sewers discharging their contents into water which has very little movement * * * finally settling to the bottom—filling in with alarming rapidity the berths at which large steamers are moored and which we have constantly to dredge to keep sufficient depth of water for all practical purposes on this account."

In a report made to the New York Dock Co. by C. C. Hopkins, Consulting Engineer, it is estimated that from Jan. 1 1905 until the winter of 1910, dredging at the rate of 120,000 cu. yds. per annum at a cost of about 17 cents per cu. yd. had been necessary in the slips of this Company, probably half of the material removed being deposited from sewage.

1499 It is not possible to obtain a reliable figure for the dredging that is actually required on account of sewage deposits, first, because no distinction is made as to the character of mud deposits removed, and, secondly, because this is only done occasionally, at intervals of perhaps several years, when required, and then often covering different areas; but, aside from the actual expense of dredging, the inconvenience to shipping in carrying on these operations in such congested streams as the Gowanus Canal, Wallabout channel, Newtown Creek, Harlem and Passaic Rivers, and the Kill von Kull, is very considerable and indirectly results in a financial loss.

The following two estimates based upon theoretical considerations, probably furnish closer limiting values than could be arrived at with certainty from deductions drawn from dredging operations.

Estimated Cost of Dredging Deposits from New York Harbor.

NOTE.—These are based upon the populations and sewage flow of the entire metropolitan district, as estimated for the year 1910, and upon such assumption as to the amount of solids deposited from each gallon or cubic foot of sewage and the percentage of moisture in the dredged material as seem reasonable.

Population of metropolitan district in 1910...	34.2	6,383,000
	A201	
Dry-weather flow of sewage in 1910.....	"	796 mgd.

Minimum Estimate.

Solids suspended in sewage..... 125 ppm.
Solids deposited from sewage..... 50 ppm.
Moisture in deposits..... 85%

Then by diagram $\frac{20.2}{A203}$ attached, the volume of sludge deposited .....1.7 cu. yds. per mg.
Total volume deposited per annum 796 x 1.7 x 365..493,900 cu. yds.
Deposits per annum, per 1,000 population.....77 cu. yds.*

1500

Maximum Estimate.

If, with the above estimates of population and sewage, we assume

Solids suspended in sewage..... 200 ppm
the harbor ..... 6,000 x 160 x 960,000 cu. yds.
Moisture in deposits 90%

Then, by diagram $\frac{20.2}{A203}$ the volume of sludge deposited ..... 5.0 cu. yds. per mg.
Total volume deposited per annum 796 x 5 x 365..1,452,700 cu. yds.
Deposits per annum per 1,000 population.....228 cu. yds.

Taking 160 cu. yds. deposited annually per 1,000 persons as a reasonable figure and 6 millions as the population connected with the sewers, the—

Annual volume of sewage deposits in the harbor ..... 6,000 x 160 x 960,000 cu. yds.

If, to this, we add an equal volume as due to detritus added from street washings *and* we have a—

Total volume of deposits in harbor per year.... 1,920,000 cu. yds.

The cost of removing these, if estimated at 20 cents per cu. yd. would be $384,000 per annum, which, capitalized at 4½%, represents a sum of $8,533,333.

If to this we add the cost of the Gowanus Flushing Tunnel, $980,310.76 (plus or minus a sum depending on further test of the pumping plant) as made necessary by the pollution of Gowanus Canal, we have a gross capital sum amounting to $9,514,144.

*Mr. C. C. Hopkins estimates 367 cu. yds. 90% moisture per 1,000 population, but this is based on assumptions of 347 ppm solids in suspension, 60% of which are deposited. These facts are derived from experience in chemical precipitation in England and are not strictly applicable, nor do they allow for subsequent digestion, consolidation and gasification of the deposits.

b. Losses Due to Impurities in the Water.

Where acids due to certain trade wastes predominate, the corrosion of submerged metallic substances proceeds with increased rapidity. Mr. J. H. McConnell, Agent, Harlem River Towboat Line, states* that the acid which occurs in the harbor water eats the solder off outboard condensers.

It would appear, too, that ordinary sewage is prejudicial
1501 to condensers. For instance, A. J. Hudson, Mechanical Engineer, in reporting to Commander W. J. Sears, Superintendent of Ferri-s, says, with reference to the Staten Island Ferry Boats, that within a period of less than 12 months after delivery of the boats to the Department "it was found necessary to remove and renew the condenser tubes of each of the boats in their entirety" at a cost of not less than $17,000 for material alone to which several thousand dollars should be added for the cost of labor. The harbor water which leaked through the rubes and so found its way to the boilers subjected the latter to severe damage as well, although the extent of this damage to the boiler is difficult to separate from that due to the fresh water from Staten Island which was itself found to be deleterious but in Mr. Hudson's opinion it is believed to be greater than the damage to condensers given above. At present a more resistent metal is used for the tubes so that it seems possible that they may last two years or more before renewal.

At the Navy Yard trouble by the pitting and "dezincification" of condenser tubes has been experienced but although it is believed that this may be accelerated by ammonia, or possibly acids, contained in the sewage, the chief cause is attributed to "galvanic or electrochemical action" induced by the salt water.*

The Standard Oil Co.** have not noted any corrosion of condenser tubes or other metal work on their boats that could be laid to the pollution of the harbor, but Mr. W. C. Besler, Vice President and General Manager of the Central R. R. of New Jersey writes*** that "there is more or less corrosion of condenser tubes and
1502 other metal work on our boats, partly caused, no doubt, by the pollution of New York harbor."

Although the damage done to condensers is more keenly felt than that experienced in other ways, the corrosion of metals is generally increased when brought into contact with acid wastes.

Mr. Wm. G. Coxe, President of the Harlem and Hollingsworth Corporation of Wilmington, Del., writes that they have found it advisable to use iron rivets on car floats and tug boats that are to remain in the vicinity of the sewer outlets in New York harbor, as steel rivets have been found to corrode rapidly under these conditions.

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*Letter of September 18, 1911.
* Letter of F. R. Harris, Civil Engineer, U. S. N., Nov. 18, 1911.
** " " O. L. Halenbeck, Lighterage Dept., Nov. 20, 1911.
*** Letter of November 21, 1911.

At the Williamsburg Power Station of the Transit Development Co. of Brooklyn, located on the Wallabout Channel at the foot of Rush Street, the condenser tubes, pumps and piping are corroded by the water to such an extent, according to Mr. C. E. Rochl, Electrical Engineer of the Company, that the cost of maintenance is increased by probably from $50,000 to $60,000 a year.

Besides corrosion, trouble is caused at this station by deposits which collect on the tubes of condensers, clogging them and interfering with their proper use. The water of the Wallabout is, at the above power station, so foul that the screens in the intake tunnel leading to the condensers have to be regularly raised and cleaned at intervals of from 4 to 8 hours. In spite of this screening, the condenser tubes have to be cleaned about once a week. If practicable, this would be done oftener, although there are from 5,000 to 8,000 tubs in each of the 8 condensers.

At the Eastern Power Station (at the foot of Division St.) and the Central Power Station (Gowanus Canal near 2nd St.) the conditions are said to be much the same, but the results are not felt so seriously, as jet condensers are employed instead of surface condensers at these plants.

The Chief Engineer, Marine Department, N. Y. C. & H. R. R. R. Co., believes that while no serious trouble has been experienced from this source with the boats of his Company in general, there has been some difficulty through corrosion of condenser tubes, pipes and pump fittings in vessels using the water of Newton Creek.*

1503

The Wheeler Condenser & Engineering Co., who are among the largest manufacturers of surface condensers, are of the opinion that "The presence of sewage in the water causes a very rapid deterioration of the brass tubes used in condensers." They mention one power plant in New York where the cost for renewals amounts to from $50,000 to $70,000 annually. Realizing the injury caused in this way large sums have been spent by numerous concerns in an effort to find some more resistant metal as a substitute for brass, but, so far, without success.

Aside from the deterioration of metals sewage pollution has been found, under certain circumstances, to injure cement mortar and concrete to a serious extent. This is usually supposed to be due to the withdrawal of the oxygen by bacteria from sulphates contained in the sewage, leaving sulphides to form sulphuric acid by combining with the water. The sulphuric acid is then free to act upon and disintegrate the cement. The rapid deterioration of the Los Angeles outfall sewer is a well known case in point.

No such deterioration has been observed by the Department of Docks and Ferries on the large amount of sea wall built by them. Such difficulty as has occurred in the past is attributed to an improper mixture or to exposure to the open water during construction. With the dense surfaces secured by moulding massive blocks

*According to the N. Y., N. H. & H. R. R. Co. this action seems to increase from year to year in N. Y. harbor.

of 25 to 80 tons each on land and placing them with derricks after setting for about a month in air, no further trouble has been experienced. Concrete work in the polluted waters of Gowanus
1504 Canal and Newtown Creek has been laid so recently, however, that opportunity for final deductions has not been afforded.

At the Navy Yard there has been serious deterioration of concrete in quay walls and dry docks. Mr. F. R. Harris writes: "We do not know that such deterioration has ever been proved to result from polluted water." In constructing their sea walls in recent years it has been inundated by the tides, in some cases, while fresh, "leaching out some of the concrete and permeating the mass with salt water." Between successive layers, therefore, cleavage planes would form "in which, in spite of cleaning off, there would be a sediment of salt. It is probable that oil and greasy substance from sewer pollution helped to define this cleavage plane by settlement on top of the layer of concrete placed, although this would not appear so evident, as the surfaces, of course, were carefully washed off and cleaned before placing concrete on top of them."

Inquiry of the Central R. R. of New Jersey and of Mr. Fort, Chief Engineer, Bureau of Sewers, Brooklyn, and of the Standard Oil Co., fail to bring out evidence that even in the Gowanus Canal or Newtown Creek has concrete been found to be injured by the pollution.

It is not possible to estimate the gross loss due to the pollution of the waters of the harbor, but from the few opinions and examples given, it may safely be assumed to amount to several hundred thousand dollars a year.

c. Losses due to Gases Liberated from the Polluted Water and Deposits.

Losses due to liberated gases are incurred by deterioration through chemical action, by deleterious influence on the health of persons in the neighborhood and by depreciation in the value of real estate. Such losses are very difficult to estimate in dollars and cents,
1505 but may be very great. It is well known that white lead paint used on vessels is rapidly discolored by the H_2S liberated by sewage and sewage sludge during the process of putrefaction. This action is particularly energetic in such waters as those of Gowanus Canal, the Wallabout Canal and Newton Creek. It occurs to a less extent in the sewage polluted slips and the Harlem River.

Losses of this kind have not been observed by the Standard Oil Co. [xx] or by the Department of Docks and Ferries [1] but have been noticed by the Central R. R. of New Jersey, especially on freshly painted steel car floats lying in the vicinity of Pier 10, North River, on which, after a few days, a "black, slimy substance" is in evidence.

[xx] Letter of O. L. Halenbeck, Lighterage Dept., Nov. 20, 1911.
[1] Letter of C. W. Staniford, Chief Engineer, November 20, 1911.

Mr. H. J. Horn, Ass't to Pres't N. Y. N. H. & H. R. R. Co., writes[x] that "there is considerable deterioration in the paint which is applied to the underbodies of vessels, and as soon as the metal surface is unprotected by paint it begins to corrode and pitts very rapidly. We believe the above conditions are due to the increasing pollution of the waters of New York harbor."

Mr. John J. Amory, President of the Gas Engine & Power Co. and Charles L. Seabury Co. of Morris Heights, has not observed material damage done to vessels by the polluted water of the harbor*m* except by the discoloration of paint. Considerable corrosion occurs as well, but this "is not of sufficient amount, in our opinion, to be worthy of any great consideration, at least under present conditions". The damage done in these ways he has not found to be "more noticeable in the Harlem than it is in the Hudson or East Rivers.

It is commonly thought that so long as the waters are not already saturated with them, gases developed on the bottom with their
1506 corresponding odors will be absorbed. This is not so, as is evident from odors that exist at outfalls, such as at Deer Island in Boston harbor, where there is a large per cent. saturation of dissolved oxygen. Large bubbles such as occur in Gowanus Canal and many other localities rise quickly to the surface without giving time for absorption, which is the case of the gradual evolution of gas in minute volumes will still be given off in part at the surface with a freedom depending on the relative pressures of the specific gas in the water and in the atmosphere. The evolution of such gases as sulphuretted hydrogen is therefore undesirable whether the overlying water is saturated or not.

The odors accompanying such gases, if not directly injurious to health, are at least offensive and objectionable. The offensive conditions due to this cause along the Gowanus Canal and Newtown Creek are acknowledged by all.

The New York Dock Company complains of odors of this kind due to the discharge of sewage mixed with the water pumped from Gowanus Canal at and for a quarter of a mile in either direction from the foot of DeGraw Street, Brooklyn.*

Similar nuisances exist in many localities, such as the vicinity of slaughter houses, where there is gross pollution of the water or of the bottom.

In connection with the use of polluted water for condensers, Mr. Roehl of the Transit Development Co. states: "A rather offensive odor is at all times noticed from the harbor water when the same is circulated or the temperature of the same is raised by passing through the condensers."**

NOTE.—Referring to the effect of gases given off by harbor deposits, I was informed by Lieut. E. H. Tillman, U. S. N. some years ago, that vessels painted white would be badly discolored by lying

[x]Letter of November 25, 1911.
*Letter of September 22d, 1911.
**Letter of September 28th, 1911.

1507 in the basin at Baltimore for a single day. The same effect is seen in steamboats plying in the Passaic River, which appears to have been singed in a fire.

Mr. Oscar F. Lackey, Harbor Engineer of Baltimore, writes (November 22d, 1911) that, so far from injuring concrete in Baltimore harbor, the pollution appears to afford a certain protection by the thick coating which forms on the surface.

To this may be added the protection to piles and other timber work submerged in salt water from the teredo afforded by sewage pollution to which this sea worm is peculiarly sensitive. In fact it was proposed by an Engineer of the Baltimore & Ohio R. R. that a certain amount of sewage be discharged continuously into Baltimore harbor to provide immunity from this pest, which in the present condition of the harbor is not found there.

d. Loss Due to Injury to Fisheries.

It is well known that certain fisheries, especially the shad fisheries, have decreased rapidly in New York harbor during the past 15 years. It is true that the catch of shad was much larger the past season than for several years but this is explained by the fact that the Hudson had been previously stocked with large numbers of young fry. It is noted, too, that the decline in the shad catch is not confined to New York harbor, as shown by the following figures:

*Pounds of Shad Caught in the United States.**

1880	18,075,000
1888	35,737,000
1897-9 (each year?)	49,787,000
1908	27,641,000

Interviews have been had with Mr. R. A. Widenmann, Superintendent of Marine Fisheries, and Mr. Wyeth, Engineer of the New York State Conservation Commission, who have given information concerning the condition of the fish and shell fish industries about New York and on November 17th a trip of inspection of the waters around State Island with reference to pollution of shell fish
1508 was made with Mr. Widenmann, representatives of the New York and New Jersey State Boards of Health, and others. But I have not been able to secure definite figures of the extent or value of the catch for successive years.

The following figures, however, give an idea of the importance of the fisheries to the states of New York and New Jersey*:

*U. S. Census.

Amount and Value of Catch for the Year 1908.

	New York.		New Jersey.	
	Amount.	Value.	Amount.	Value.
Clams—hard	101,000 bu.	$223,000	273,000 bu.	$318,000
soft	66,000 bu.	54,000	20,000 bu.	11,000
total (including surf)	188,000 bu.	292,000	306,000 bu.	336,000
Mussels	8,173,000 lbs.	8,200	287,000 lbs.	1,400
Oysters—market	1,849,000 bu.	2,173,000	920,000 bu.	884,000
seed	614,000 bu.	381,000	1,667,000 bu.	485,000
total	2,463,000 bu.	2,553,000	2,586,000 bu.	1,369,000
Total shell fish		$2,853,200		$1,706,400
Shad	360,000 lbs.	$27,000	3,604,000 lbs.	$229,000
Total:				
Fisheries	76,485,000 lbs.	$4,594,000	74,827,000 lbs	$3,069,000
Men employed	6,775		7,231	
Capital invested		3,606,000		1,714,000
Wages and salaries earned		1,177,000		744,000

The value of the New York fisheries, which are chiefly carried on in the vicinity of New York harbor, constitute 9% of the total for the United States, and of the New York fisheries oysters represent 35% of the total in value.

The value of the oyster catch in New Jersey is 45% of that of all fisheries.

1509 In both states the catch of oysters has decreased somewhat during the past few years. About New York the larger oyster dealers appear desirous of protecting their trade by abandoning oyster ground known to be most polluted, such as in the Harlem River, Upper Bay, Newark Bay, Arthur Kill and the part of Raritan bay between Perth Amboy and Lemon creek, although parts of these waters are used for raising seed oysters and oysters for the market are no doubt taken surreptitiously.

The most important oyster and clam beds open to suspicion are perhaps those in Jamaica Bay. The capital invested here is large and many men are employed. The sewage effluents from Bergen, Second and Paerdegat creeks pollutes all the northern shores of the bay so that the oyster interests are endeavoring to secure a more thorough treatment of the sewage by the city.

These unfavorable conditions have probably been the chief cause for the falling off in both the shad and shell fisheries, and, with the inspection necessary and the abandonment of polluted laying-grounds there has been a considerable loss directly due to pollution to which, however I have not been able to assign a definite value.

Conclusions.

From the information given above, which has been collected from a variety of sources somewhat at random, we may draw the following conclusions:

1. The pollution of the waters of New York harbor results in an annual expense for dredging probably amounting to about $200,000, or, if we include the Passaic river, Newark bay and Kill von Kull, to about $350,000 (34.2) (A214)

2. The impurities contained in the water cause in some cases rapid deterioration of condenser tubes and other metal sur-
1510 face with which they come in contact and necessitate frequent cleaning of condenser tubes, resulting in a total loss of several hundred thousand dollars a year.

3. The loss due to discoloration of paint on vessels and to the value of real estate on the water front cannot be estimated, but in certain localities and in total, is very great.

4. The loss due to injury to the shad, oyster, and clam fisheries is large, and, with the limit of pollution reached in the Hudson river and Jamaica bay, the losses in the shad fisheries in the former and in shell fisheries in the latter are liable to be greatly increased within the next ten years.

(The report just referred to is accompanied with a blue print, marked File No. 202 Acc. No. A203 Volume of Sludge of a given percentage of Moisture by the Dried Solids in suspension in sewage, Oct. 1911.)

By Mr. O'Sullivan:

Q. Mr. Allen, did you make any studies or observations or investigations relative to pollution of the harbor by garbage and refuse?

A. I did.

Q. As the result of your investigations and observations did you collect that material and submit it as a report to the President of the Metropolitan Sewerage Commission?

A. I did, August 11th, 1911.

Q. Will you now read the report you made to the President of the Metropolitan Sewerage Commission on August 11th, 1911?

A. Yes, sir.

Recross-examination by Mr. McCarter:

Q. Is the report that you are about to read from made up of data collected by you from sources, in the same general way as the data collected by you on the previous report you just read?

A. Not entirely. In this report there is more that is taken from actual observation.

Q. And made by yourself?

A. Made by myself, yes.

1511 Recross-examination by Mr. Riker:

Q. Mr. Allen, do you distinguish in this determination on garbage and refuse matters, discharged directly into the water, do you distinguish that from matters discharged through sewers?

A. Yes.

Q. This has nothing to do with matters discharged through sewers then?

A. No.

Mr. Riker: I object to it on the ground that it is irrelevant and immaterial. Has nothing to do with the discharge through a sewer.

The Commissioner: Note the objections of counsel for defendants.

Mr. O'Sullivan: The contention of the Complainants may it please the Commissioner, shall be and is and has been that these waters are now so overburdened by pollution from various sources that this mammoth nuisance which is threatened by the State of New Jersey would be almost unbearable from the first moment of its discharge, and for that purpose counsel for Complainants desires opportunity to show every polluting source that contaminates those harbor waters to the loss of property, and menace to health also.

Mr. Riker: While it appears from the statement of Counsel for Complainants that the City of New York is in various ways polluting the harbor by the discharge of garbage and refuse and sewage into the waters of the harbor, and thereby convicting itself of creating a condition which is injurious to itself, also objectionable, I still persist that this litigation has nothing to do with garbage and refuse as distinguished from sewage.

Mr. O'Sullivan: Counsel for Complainants desires to answer the comment of Counsel for defendants by stating that the pollution that will be spread upon this record as affecting this harbor, not only comes from the City of New York, but it comes from many cities in the State of New Jersey, as well as in the State of New York, notably

1512 cities like Jersey City, Weehawken, Hoboken, Bayonne, with the tremendous amount of trade waste that comes from these cities. We are trying to show, without any regard as to the particular source of a given pollution the fact that the waters are now overburdened.

Mr. Riker: Now, Mr. Allen, I understood you to say that this report contains in part material collated and compiled by you from observations of other persons.

The Witness: Yes.

Mr. Riker: I object to it on the ground that it is hearsay and incompetent and irrelevant.

The Commissioner: Note the objection of counsel for Defendants.

Mr. O'Sullivan: State the contents of the report?

The Witness: (Dated August 11th, 1911) I beg to hand you herewith this memorandum concerning the Pollution of New York Harbor by Garbage and Refuse.

Garbage may find its way to the waters of the harbor:

1. By the direct and intentional disposal of it in that manner from the docks, shore and vessels.

2. By surreptitiously mixing it in with material to be dumped at sea.

3. By careless handling in loading scows or by being blown from scows by the wind or knocked therefrom by accident.

4. By careless handling in unloading or improper disposition at Barren Island or Rikers Island.

1. There is no doubt but that more or less waste material is thrown from vessels and on the beaches where liable to be floated off by the rising tide. For instance, at points on the north shore of Sheepshead Bay, vegetable and other refuse was noted, which had been deposited there. The Harbor Supervisor keeps a lookout for vessels that may dispose of garbage in this way. The large ocean liners retain garbage until docking, when it is delivered to the Street
1513 Cleaning Department. It is not probable that any appreciable quantity is thrown overboard by other vessels except trump steamers. These probably do dump garbage at times into the water. The Harbor Supervisor believes that by police supervision the practice is now quite exceptional.

2. It is possible that some garbage occasionally gets mixed in with cellar dirt since the night removal of garbage has been inaugurated, but there is no evidence of this, and the Harbor Supervisor believes such cases, if occurring at all, to be very rare. It is on condition that only heavy matter is dumped off Scotland Light that permission has been given to dump at all stages of the tide instead of during the ebb only, the latter requiring tows to pull against the tide in one direction at least.

The attendant at the West 97th Street municipal dump states that each load is inspected as it comes to the dock. It should consist exclusively either of garbage, refuse or cellar dirt. If these are mixed, the load is not received. Where, as at this point and West 60th Street, a private dump is near, the load is frequently taken there, where, on payment of 35 cents, it is received, and in this way some garbage is liable to get mixed with the cellar dirt. It is proposed to raise the charge of 35 cents to 90 cents per load. This would deter those handling the material from mixing different classes of wastes in order to insure its acceptance at the City dumps.

The refuse received is sorted at the dump, rags and tin cans being taken out. The tin cans are taken in a separate scow to some point near Perth Amboy where they are melted, saving the solder and converting the iron into window sash weights.

3. The Supervisor of the Harbor is of the opinion, however, that more or less garbage may fall into the water while loading scows. Dumps for loading from Manhattan are located at Canal, 47th, and 97th Streets on the Hudson river, and at Clinton, 46th, 107th and 139th Streets on the East and Harlem Rivers. An in-
1514 spection made at the West 97th Street dump August 10, leads to the opinion that but little can be lost in this way. The deck of the scow extends some 12 or 15 feet beyond the bulkhead retaining the load at each end, so that if the material was

dumped too near the end, it would merely fall on this deck, while the dumping platform extends nearly to the middle of the scow, so that there is no danger of material falling over the sides unless overloaded. The material at the sides is trimmed to line, but, in spite of this, it is possible that some material—more particularly refuse—may be blown overboard during high winds while in transit.

There are also dumps, either municipal or private, for loading refuse, cellar dirt and mud at the foot of West 30th, 39th, 55th, 79th, 96th and 133rd Streets—and East Stanton, 14th, 33rd, 40th, 60th, 71st and 133rd Streets.

Those at West 30th, 39th and 55th Streets were visited August 9th. The dumping platform extends about 15 feet toward the center of the scow so that there is little liability to let the material fall into the water unless through overloading. There was no evidence of either in the scows seen. The refuse noted included paper, steel turnings, burlap, old boxes, crates and barrels, ashes and some garbage. The Supervisor of the Harbor believes, however, that more or less finds its way into the harbor by careless handling, overloading or wind, and has recommended the use of scows with bins by the City to prevent this.

The refuse is taken by Daily and Ivans, Contractors, from Clinton Street, East River to Rikers Island to Newark Bay and to points on Staten Island for the Staten Island Rapid Transit Co. The City takes the refuse from the Hudson River to Rikers Island and to Flushing, where the Borough Development Co. receive and handle it.

1515 Garbage is all taken to Barren Island reduction plant by the Sanitary Utilization Co.

4. No floating material has been noted by me near Barren Island or Rikers Island, but a man residing on Hunts Point mentioned the fact that much refuse (including an occasional mattress) stranded on the shore there. The Supervisor of the Harbor believes that material is frequently deposited so as to be washed off by the waves and has suggested the formation of a harbor and inlet, as used on the south end of Governors Island, where material could be handled and deposited without danger of being washed away.

On the whole, while it seems probable that a small amount of refuse and garbage finds its way to the waters of the harbor, it does not appear to be of such general occurrence or in such amounts as to be a serious factor in the pollution of the harbor. The cases that do occur, are, of course, objectionable, but constitute local and temporary nuisances that require nothing further than strict police supervision.

Statement to be Appended to Report on the Pollution of New York Harbor by Garbage and Refuse, Dated August 11, 1911.

Material Collected by the Department of Street Cleaning in Manhattan, the Bronx, and Brooklyn During the Year 1910.

	Ashes.	Cartloads of rubbish.	Garbage.	Total.
Manhattan } The Bronx }	1,950,159.25	221,498.75	232,339.25	2,403,997.25
Brooklyn ..	662,085.00	143,433.00	113,724.75	919,242.75
Total..	2,612,244.25	364,931.75	346,064.00	3,323,240.00

1516 2. Disposition of Material from Manhattan, the Bronx, and Brooklyn During the Year 1910.

	Cartloads.	
	Manhattan and the Bronx.	Brooklyn.
At Sea	11,893.00	.....
Rikers Island	1,774,267.25	.....
Borough Development Co.*	.....	805,385.00
Barren Island (Garbage)	232,623.00	113,712.50
Private Dumps	90,255.00	.....
Inland Dumps	215,131.00	133.00
Incineration	25,038.50	.....
Capsized	794.00	.....
Total	2,350,001.75	919,230.50

* To Flushing Bay and some inland fills. No record kept.

3. The Amount and Disposition of the Garbage and Refuse from Queens are not available.

4. Disposition of Ashes, Rubbish, and Garbage Collected by the Bureau of Street Cleaning, Richmond, During the Year 1910.

Refuse Destructor, 8,827 tons	22,000 cu. yds.
Buried or used for filling	52,457 " "
Total	74,457 " "

(Dated September 14th, 1911.)

Redirect examination by Mr. O'Sullivan:

Q. Mr. Allen, did you make any investigations and experiments relative to the discharge of sewage at Mount St. Vincent?

A. I did.

Q. And did you collate your experiments and observations relative to the discharge of sewage from Mount St. Vincent and submit the report to the President of the Metropolitan Sewerage
1517 Commission?

A. I did.

Q. When, what date?

A. May 25th.

Q. Will you now read the report that you made to the Metropolitan Sewerage Commission, to the President of the Metropolitan Sewerage Commission on May 25th, 1911?

A. May 25th, 1911.

Recross-examination by Mr. McCarter:

Q. How much of this report, Mr. Allen, is made up of conclusions based on your own observations and how much is made up of conclusions and ideas based on information given to you by other people?

A. This was made on my own observations.

Q. Wholly?

A. There were one or two assistants with me who assisted in the work. We were in boats, and those that were there may report what they saw.

Mr. McCarter: I object to it, because it is at the best—because evidently it is based on hearsay, it is irrelevant.

Recross-examination by Mr. Riker:

Q. Where is this institution located?

A. Just north of the New York City Line on the Hudson River.

Q. On which side?

A. The east side.

Q. Within the State of New York?

A. Yes.

Mr. Riker: The same objection.

The Commissioner: Note the objection of Counsel for Defendants.

Redirect examination by Mr. O'Sullivan:

Q. State the contents of the report?

A. 1. General conditions. (Dated May 24th, 1911.) Predicted low tide occurred at about 11:30 A. M. Salinometer determinations at 1:20 P. M. indicated 76% land water.

During low water the vicinity of the outlet was grossly polluted. The bottom near the shore was covered with small fragments of toilet paper. There was a distinct odor of fresh sewage and the wa'er contained much light flocculent matter, many feces, a
1518 decided scum and large numbers of white grease particles. After the flood current had become well established—say 3

hours after low tide—the character of the water improved greatly and the sewage odor disappeared.

Between 11:50 A. M. and 2:30 P. M. several surface floats consisting of blocks of wood, were set adrift at the outlet. Float No. 2 was carried down by the ebb along the shore, and at 12.03½ P. M. went ashore about 60 ft. north of Mt. St. Vincent dock.

12:15 P. M. A slight current upstream was noticed at the outlet.

12.50 P. M. Thick scum and feces noted at bathing beach south of outlet.

12.57 P. M. Float No. 4 was set out from outlet which went ashore, about 40 ft. to the south, on an ebb current.

1:03 P. M. Slack water occurred near the shore at about this time, or 1½ hours, after low water.
1:07 P. M. Float No. 4 set adrift again at outlet.
1:12 P. M. " " " 60 feet from shore and 10 feet upstream from outlet.
1:21 " " " " " 10 feet down stream of S. W. corner of bathing dock
2:21 " " " " " 10 feet down stream from bathing dock, and 30 feet from shore.
1:58 " " " " " 6 set out as before, drifted down stream.
2:00 " " " " " 80 ft. down stream and 40 ft. from shore. Many grease particles noted at this time.
2:03 " " " " " opposite outlet and 160 ft. out.
2:21 " " " " " 115 ft. north of outlet and 150 ft. off shore.
2:34 " " " " " 165 ft. north of outlet and 50 ft. off shore.

68 lengths of 48" pipe were noted on the shore for use in proposed submerged outlets.

2. Uranine Experiments.

Uranine was dumped in the sewer manhole at Tibbets Brook by Mr. C. A. Holden, about 7000 ft. above the outlets as follows:

1519

11:05 A. M.	1.0 lb.	1:00 P. M.	0.5 lb.
:18 "	0.5 "	:15 "	0.5 lb.
:30 "	0.5 "	:30 "	0.5 "
:45 "	0.5 "	:45 "	0.5 "
12:00 M.	0.5 "	2:00 "	0.5 "
:15 P. M.	0.5 "	:15 "	1.0 "
:30 "	0.5 "	:30 "	1.0 "
:45 "	0.8 "	:45 "	1.0 "

The results were observed by Messrs. Gregory, Morse and Barrey and myself from rowboats near the outlet and toward the end by Mr. Holden and you.

12:31 P. M. The color appeared at outlet, having taken 1 hour 26 minutes in its passage.
12:40 " " The field was as per sketch.
(Here followed a diagram)
12:57 " " The field was like this
(Here followed a diagram)
1:07 P. M. The west end of the field swept southerly by the current.
1:21 " " The field entering bath house dock as per sketch.
(Sketch was here inserted)
2:15 P. M. Color diffused throughout interior of bathing dock—very strong at south end.
2:30 " " Color field as per sketch.
(Sketch was here inserted.)
3:30 P. M. } Color field off bot house dock ½ way to Ludlow.
3:45 P. M. }
4:00 " " Followed color detached field about 40′ x 80′ in size to within about 600 ft. of the Ludlow dock (about ½ mile from outlet.)

Notes on Float Experiments at Bronx Valley Sewer Outlet Made by R. B. Morse May 24, 1911.

Tide Ebb—Nearly Low.

Float #1.

Put in at 11:44.
Upstream to 11:48—Position at 11:48, 60′ from shore, 75′ north of sewer.
Opposite outlet, 75′ out, at 11:51.
11:55—40′ from shore, 300′ south of outlet.
11:59—60′ from shore, 200′ south of outlet.
Swings out to 80′ or 90′ from shore and starts downstream stops 25′ from shore about 450′ south of outlet at 12:02, then starts slowly south along the shore.
Enter- cove at bathing beach near Mt. St. Vincent Sta. at
1520 12:10 and gets into dead water.
Still in cover at 1:20.

Float #3.

Put in at 1:22.
Moves up stream and out.
At 1:33—170′ from shore and 100′ north of outlet.
Starts downstream.
150′ from shore and opposite outlet at 1:35.
At 1:44 starts to move upstream near shore, it being 50′ from shore and 200′ below outlet.
Swings out at 1:55, 200′ from shore and 100′ south of outlet.
2:05—50′ from shore and 300′ south of outlet.
Starts upstream near shore.
At 2:20 float is opposite south end of swimming pool north of outlet, and about 40′ from outer face.

At 2:25 float is opposite north end of pool—25' from outer face.
At 2:35 float strands on short 100' north of north end of pool.

(This report is accompanied by a map showing location of outlet of Bronx Valley Sewer, May, 1911, and showing the mark I L—1136—2.)

Q. Mr. Allen, did you make a special line of investigation relative to the dumping of cellar dirt at Scotland Light?
A. I did.
Q. And from the facts that you observed and collected, did you fashion a report that was submitted to the President of the Metropolitan Sewerage Commission?
A. I did.
Q. On what date?
A. On July 28th, 1911.
Q. Will you now proceed to state what that report was?

Recross-examination by Mr. Riker:

Q. Mr. Allen, is this report a compilation of facts observed by you?
A. Yes.
Q. Does it contain statements made by others?
A. Not with reference to the dumping of cellar dirt excepting as regards the inspection of boats as they passed through the Narrows. There the statement was made by the Harbor Inspector as to the routine of that inspection, but the inspection of the dumping of the cellar dirt was made by myself.
1520½ Q. What is it that you designate as cellar dirt?
A. Cellar dirt is the material that is taken from excavations, for new buildings. That sinks to the bottom. It is not dredgings as a rule, but brick and mortar and excavated material.
Q. Where did you get the information as to the place from which this cellar dirt came?
A. I do not know as I had any information in regard to the source of it, except from the reports, the published reports of the Harbor Inspector.
Q. Is your report that you are about to read based at all on those reports?
A. No, except as to the source of the material.

Mr. Riker: I object to the reading of the report into the record upon the ground that it is not a memorandum to refresh this witness' memory of facts observed by him. That it is admittedly in part based upon hearsay, and that as opinion evidence, it has no foundation of fact proved, upon which it can rest, and that the witness has not qualified as an expert to testify on the facts.
The Commissioner: Note the objection of Counsel for Defendants.

Redirect examination by Mr. O'Sullivan:

Q. State the contents of that report?

A. (Dated July 28, 1911.) I beg to report as follows regarding an inspection of the dumping of cellar dirt off Scotland Light Vessel, made yesterday by courtesy of the Supervisor of the Harbor on the tug "Cerberus."

Each tow with its load is noted as it passes out at the Narrows by one boat of the Supervisor of the Harbor and checked by a second boat stationed at the dumping ground 4 mi. E. S. E. of Scotland Light vessel. (The same applies to mud scows except that these are dumped 2 mi. S. E. by E. of Scotland Light Vessel.)

The dumping of 10 scows (5 tows) was observed, although it was so dark in the case of the last 4 that the contents could
1521 not be seen.

The scows contain from 4 to 6 pockets and on the arrival at the proper location, the tug gives a signal consisting of 4 whistles and a man on each barge open the gates at the bottom of the pockets, allowing the load to discharge while under way.

The material consisted of earth and refuse from the tearing down of buildings. No garbage was seen and both the Supervisor of the Harbor, Capt. C. McR. Winslow, U. S. N. and Capt. Nelson of the "Cerberus" claim that this is rigidly excluded.

After dumping the first three scows nothing was left floating but small sticks, bits of lath, etc., seldom over 2 feet in length. There were no large boards *of* timbers. These soon collected and formed a narrow field on the water surface, such as is frequently seen in the Upper Bay.

The next three loads were similar in character except that there were a good many scraps of paper from about 4 inches to 12 inches on a side and a few tin cans which remained on the surface.

As the tows got out on the ebb current, the dumping usually takes place at the end of the ebb or beginning of the flood current, which there appeared to set toward Sandy Hook.

By Mr. O'Sullivan:

Q. Mr. Allen, did you make any observations and investigations relative to deposits in the Lower New York Bay?

A. I did.

Q. Did you collate the facts observed by you and fashion them in a report, which you submitted to the President of the Metropolitan Sewerage Commission?

A. The effects were not observed by me. It was information received from others, and reported on August 7th, 1911.

Q. When you say "others" do you mean men in the employ of the Metropolitan Sewerage Commission?

A. No, mostly outside.

Q. Were they officials?

A. Yes.

1522 Q. In the Federal or State service?

A. Federal.

Q. Did you yourself gather the figures of facts?
A. I did.
Q. Then you arranged them in the form of a report?
A. I did.
Q. When did you submit that report, what date?
A. August 7th, 1911.
Q. I ask the witness now to read the report that he made on that date.

Mr. Riker: The reading of the report into the record is objected to on the ground that by the statement of the witness it appears to be entirely hearsay, and that all the witness has done is to compile hearsay evidence which is embraced in this report.

The Commissioner: Note the objection of Counsel for Defendants.

A. (Report dated August 7th, 1911.) I beg to submit the following results of an interview with Mr. Balch August 5.

Memorandum Concerning Deposits in New York Lower Bay.

In dredging the Ambrose Channel a large quantity of an offensive brown mud was removed. This covered the area indicated on the attached sketch, but the eastern and western limits were not located. This varied from 1 to 6 feet in thickness and averaged about 3 feet in 1905, where it is known from an examination of the ground that no soft material existed in 1900-1. At this time mussels and black fish (which feed on them) were plentiful here, while now they are not found. The quantity of this material removed from the Ambrose Channel (2,000 feet wide) has been about 1½ million cubic yards in 4 years.

On examination this material is seen to be composed of very fine yellowish sand filled with black particles which, combined, have a dark brown appearance.

The material was so offensive that men on the dredges were said to have been nauseated and Mr. Balch proposed a postpone-
1523 ment of the work in that vicinity until cold weather. The odor was similar to that from sewage and was very strong. A peculiar phenomenon was noticed at least once while working in this material. The dredge was covered with a thin moist greyish film. What this consisted of was not known, but Mr. Balch suggested that it might have been some form of microscopic mold.

Mr. Balch also mentioned incidentally that since 1898 deposits 10 feet in thickness had occurred off Red Hook and that considerable deposits had occurred between 72nd Street Brooklyn and the Crescent Yacht Club.

The cost of dredging the Ambrose Channel has been, including 4% interest charges, about 6 cents per cubic yard. In Coney Island Channel where the dredges are working at the higher stages of the tide only and can utilize the balance of the time on the Ambrose Channel nearby, the cost is about 8 cents per cubic yard, but would be much more if the time during low water were lost.

(This report is accompanied by a blue print showing the location of deposits of Organic Matter.)

By Mr. O'Sullivan:

Q. Mr. Allen, did you make any investigations relative to the sewerage at Jamaica, Woodhaven and Richmond Hill?
A. I did, November 16th, 1910.
Q. And did you submit a report based upon the investigations that you made of the sewerage of Jamaica, Woodhaven and Richmond Hill?
A. I did.
Q. To the President of the Metropolitan Sewerage Commission?
A. I did.
Q. On what date?
A. November 16th, 1910.
Q. I request this witness to read that report.

Recross-examination by Mr. Riker:

Q. Mr. Allen, the investigation that you made and which you say is embodied in this report, is it of original facts observed
1524 by you?
A. It was not so much an inspection as a study of the general sewerage question of that district.
Q. And what were the facts which were studied by you in that connection, where did you get them?
A. Chiefly from the Sewer Bureau of Queens.
Q. Does this report contain any original observations made by you of facts upon which your report is based?
A. It does not contain observations at all that I know of. The data used were furnished mostly by the Bureau of Sewers and by maps.
Q. Then this report is the expression of your opinion on the *the* facts furnished to you by someone else?
A. Yes.

Mr. Riker: I object to it in so far as it purports to be a statement of facts that it is purely hearsay and in so far as it purports to be opinion evidence it is based upon statements which are hearsay, and therefore has no value as opinion evidence.
The Commissioner: Note the objection of Counsel for Defendants.
Mr. McCarter: The same objection.
The Commissioner: Note the objection.

Redirect examination by Mr. O'Sullivan:

Q. Were the facts that you collected from the Bureau of Sewers of Queens made up of public records in the Department of Sewers of Queens?
A. They were.
Q. And were the maps that you used, were they furnished to you

by the borough of Queens, were they maps that were parts of the records of the Bureau of Sewers of Queens?

A. They were.

Q. I ask the witness to state the contents of that report.

Mr. Riker: The objection is renewed on the same grounds.

Mr. McCarter: The same objection.

The Commissioner: Note the objection of Counsel for Defendants.

A. (Report dated November 16th, 1910.) I beg to hand
1525 you herewith the results of a study of the conditions affecting the design and development of the sewerage of Jamaica, Woodhaven and Richmond Hill.

In general the conclusions arrived at are that it is desirable to use the separate system so far as practicable, and that the sewerage from this area may best be taken care of, until more permanent works are available, by the present Jamacia disposal plant modified to secure more efficient and economical results.

The Sewerage of Jamaica, Woodhaven, and Richmond Hill.

1. Existing Conditions.—That part of Queens comprised within the old corporate limits of the Village of Jamaica is provided with sewers built on the separate system under a plan approved June 1896. The minimum size is 8".

Areas.

	Acres.
Area of Queens Borough draining to Jamaica Bay	30,518
Area of dry land in Queens Borough draining to Jamaica Bay	23,328
Area of Jamaica draining to Jamaica Bay	2,311
Area of Jamaica provided with sewerage	1,900*
Area of Woodhaven and Richmond Hill for which sewerage plans are approved:	
District 40A	893
" 40B (exclusive of 40 acres of park)	523
" 40C	224

2. Probable Conditions in 1940.

Estimated Population and Sewage, 1940.

	Population.	Max. flow = Q mgd.
Jamaica	52,000	12.5
Woodhaven and Richmond Hill—		
District 40A**	27,000	6.1
" 40B	22,500	4.8
" 40C***	43,000	8.5
	144,500	31.9

*Rep. of R. Hering to Bd. of Est. Jan. 1908.

**Extended to Jamaica.

***Extended to Liberty Ave.

1526 By this time with the effect of the improvements contemplated by the Long Island Railroad Company and the neighboring and prospective improvements of the water front in Jamaica Bay, a population density of the above areas approximating 20 to 25 persons per acre may be expected, diminishing to the south to perhaps less than 5 per acre, although this density will depend very much on the rate at which the Jamaica Bay improvement is put through in the vicinity of Canarsie.

3. Sewerage of Jamacia. The collecting system converges to a 24" trunk sewer running southwesterly on Lincoln Ave. Below Van Wyck Ave. at elevation 15.51, a 2'-2" x 3' 3" trunk sewer extends in a southerly direction to the Jamaica disposal plant near the Old South Road. The fall in this distance is 5.26 feet. From the disposal plant a horse-shoe shaped conduit about 20 sq. ft. in cross section carried the effluent 2,000 feet to a wooden flume, by which it is conveyed some ¾ mile further to Jamaica Bay. The precise grade and capacity of this flume are not known.

The gradient of the main sewer on Lincoln Ave. is so slight,—less than 0.1 per 100,—that the estimated velocity when full is not much over 2 feet per second and its capacity but about 4 mgd. The estimated capacity of the trunk sewer leading to the disposal plant is 7.3 mgd. To provide for the forecast population of 1940 capacities of about 10.3 and 16.7 mgd. will be required by which it is evident that this main sewer will be inadequate. The Bureau of Sewers appreciates the fact that the system as a whole will not serve the population expected in a few years, and looks forward to its entire reconstruction. As the minimum size is 8 inches, it would appear that much of the collection system might be incorporated into any new system planned with a corresponding saving in cost.

1527 On account of the long distance required to carry storm water and the flat nature of the ground, which involve extra expense in constructing separate sewers and many probable points of interference, Mr. A. Schreiner, of the Bureau of Sewers, is of opinion that the sewers draining to Jamaica Bay should be on the combined plan with storm overflows at suitable points. This is a fundamental matter that requires an early decision in formulating any general scheme for the future.

The objections to the adoption of combined sewers, as well as the advantages, are of considerable weight. In the first place, as the grades must of necessity be above mean tide level, it would be necessary in order to provide adequate drainage to the areas within a mile or two of Jamaica bay, to collect by low-lying sewers to subsidiary pumping stations and pump to the main sewers. Such low level sewers would not, probably, be on the combined plan, but the multiplication of pumping plants would not appear economical.

Again, during times of overflow, large volumes of crude sewage would find their way to Jamaica bay or its tributary creeks at points where the water is shallow and the currents small. And the sewage diverted at such times to any plant for purification would be so diluted as to make its treatment more costly and less efficient.

As to the objection to the separate system above noted, that of in-

terference between the two systems would be largely obviated by the collection of the sanitary sewers *ro* interceptors placed below tide level, permitting storm drains to cross over them. And the increase cost of the double system would not be so great as might be expected as storm drains would not have to extend beyond points to which gutter flow could be utilized, the construction of a large part of
1528 the system could be deferred for an indefinite time, while the main long lines of outfall would have to be built in case the combined system were adopted as storm overflows.

Without passing hastily upon so important a question, it seems to me that the advantage of the separate system for Jamaica overweight those of the combined system.

4. Sewage Disposal for Jamaica. According to the report of Mr. Hering of Jan. 1908, already referred to, the Jamaica disposal plant cost about $108,870 in 1903, handles on an average 1.5 mgd., reaching during wet periods 2.4 mgd. of sewage from a population of 19,000 at a yearly cost of $16,000 or $30 per million gallons, and has a capacity of 3 mgd. Of the cost of operation, $1,000 goes for chemicals.

At this time Mr. Hering was of opinion that the money spent for chemicals was wasted, that a considerable saving would be effected by the employment of a technical man familiar with sanitary work, and that as good results might be reached by a slight modification in the plant, but that as soon as practicable the entire plant should be reconstructed so as to provide septic tanks with eight hours' storage, sprinkling filters 6 or 7 feet deep and settling basins holding about 4 hours' flow. The cost of such a plant would be in the neighborhood of $85,000.

If, as now seems probable, it should be found best to intercept the present and prospective lines of outfall sewers leading to Jamaica bay by sewers laid at comparatively low elevations for the purpose of conveying the sewage to one or more central plants for treatment, it will probably be of no advantage to abandon the existing plants in Brooklyn and Queens, which are already inadequate in size, out of date, and, except perhaps as pumping stations, are not adapted to fit in with any general plan likely to be recommended.

In view of the fact that no plan conforming to the most desirable lay-out for the future can be made available for several years,
1529 it will probably prove advisable to utilize the present plant, modifying its operation and enlarging it as may be found necessary to tide over the intervening time. To this end, the following suggestions made in part by Mr. Hering in his report of January, 1908, appear worthy of consideration at this time.

1st. Increase the lime and copperas during the summer months so as to increase the percentage of suspended solids and bacteria removed from about 67 to 80 or 90. This will cost for chemicals about $3 or $4 per million gallons.

2nd. Suspend the use of chemicals entirely in winter weather if necessary to curtail the expense due to increased cost in the summer when putrefaction is more active and offensive. During such periods

about one third of the total organic matter or two-thirds of the total suspended matter and bacteria may be removed.

3rd. Remove a part of the baffles in sedimentation tanks so as to reduce the velocity and promote deposition. As operated at present, the sewage travels about 1,373 feet in 6½ hours or at the rate of 3½ feet per minute, whereas one-half this velocity would be desirable. The sewage, for instance, might be admitted through a central wall cutting the present tanks in two when, by reducing the travel by 50% the time of sedimentation and capacity would remain as at present.

4th. Provide a competent young man to supervise the operation of the plant, make tests of the results obtained, etc.

5th. Before the capacity of the plant is reached operated under these more favorable conditions increase its capacity by the addition of more sedimentation tanks sufficient to last until the adoption of some more comprehensive scheme.

1530 5. The Sewerage of Woodhaven and Richmond Hill.—The sewerage of Woodhaven and Richmond Hill constitutes but one general problem. Plans have been approved and contracts in part advertised covering:

415	acres	in	District	40A
523	"	"	"	40B
224	"	"	"	40C

The sewer bureau has adopted the combined system for these districts for the reasons stated in Art. 3 with reference to Jamaica. To avoid the multiplication of treatment plants, it is planned to carry the sewage to the Jamaica plant for this purpose; and in order to avoid the carriage of storm water by such an indirect line to its natural outlet in Jamaica bay and to permit the dry-weather flow only to be treated, storm overflows are to be provided for District 40C in Scedeker Ave. at Jamaica Ave. in Yarmouth St. at Syosset St. and in Woodhaven Ave. at Ridgewood Ave. The dry weather sewage cut off at the last point is carried in a combined sewer to Rockaway Road and Freedom Ave. where provision is made for the drainage of 500 acres from the west and a storm overflow is provided for District 40B. Continuing on Rockaway Road with a 10'—6" sewer to Leffert St., the dry weather flow is diverted into a 3' sewer which goes to the treatment plant by Rockaway Road, Panama St. and Stanley Ave., leaving the storm water to continue on by Panama St. to Jamaica bay in an 8' x 9' reinforced concrete twin sewer.

The obvious reason for intercepting the dry-weather flow so far above the treatment plant is to permit its delivery without
1531 pumping, leaving the storm water to be carried at the maximum grade obtainable to the outfall.

6. Provision for Woodhaven and Richmond Hill Sewage for the Near Future.—The area lying between Jamaica and the Borough of Brooklyn is expected to develop rapidly so that extensions to the plans already under way are likely to be called for before long

and some way of providing for its disposal will have to be decided on. This may be done in one of two ways:

a. By conveying in a temporary sewer to the present Jamaica plant.

b. By conveying it in a permanent sanitary sewer by direct line to a new treatment plant near the bay.

The treatment plant in either case would be of temporary construction and not likely to fit in with any scheme for ultimate disposal.

Scheme a.

The estimated capacity of sanitary sewers from the area under consideration to the disposal plant is estimated at:

For the year	1910	10.3 mgd.	
" " "	1940	25.8 "	and is assumed
" " "	1920—as	18.0 "	

The capacity of the 36" sewer to be built from Leffert St. is 9.6 mgd. which leaves an additional capacity of 8.4 mgd. to be provided for the year 1920. This may be had by duplicating the proposed 36" sewer to the disposal plant.

Here the sewage would pass through sedimentation tanks about 136 x 225 feet in area at a velocity of 2 feet per minute and then by the present outfall flume to Jamaica bay.

Estimate of Cost.

Trunk sewer	$52,000
Sedimentation tanks	28,000
Total exclusive of land or additional outfall to Jamaica bay	$80,000

1532 The yearly additional cost of operation by 1920, including disposal of 11,000 cu. yds. of sludge, due to the delivery of this sewage, would probably be in the neighborhood of $7,000.

Scheme b.

By this plan the 3 ft. sewer to be built from Rockaway Road and Leffert St. to the Jamaica plant would be reserved for the use of District 40A, for which it would be adequate until 1940. The maximum rate of discharge would then be 6.1 mgd. and the capacity of the sewer is 9.6 mgd.

The remaining dry weather sewage, delivered at a maximum rate of 6.2 mgd. from District 40B and District 40C would be intercepted as already planned at Rockaway Road and Freedom Ave. and carried 2,200 feet by a 26" x 39" sewer to Woodhaven and Dalrymple Aves. Here the sanitary sewage from 500 acres south of District 40C would enter and a 46" sewer designed for a maximum flow of

13.3 mgd. would extend 7,800 feet in a southerly direction to a temporary plant for plain sedimentation on a tract known as Stoothoff's or Hartman's Island on the marsh near Jamaica bay. The effluent from this plant would pass by a temporary flume 3½′ x 2′ x 2,400 feet long to Jamaica bay.

Estimate of Cost.

Sewers leading to treatment plant	$93,665
Sedimentation plant	30,000
House for laboratory, etc	2,375
Outfall flume to Jamaica bay	660
Total exclusive of land	$126,700

The maintenance charges for disposal at Stoothoff's Island are estimated at about $11,000 in 1920.

Comparison of Schemes

By the first plan there would be a saving of $46,700 in first cost and perhaps $4,000 in annual operation charges by 1920.
1923 There would be the advantage in avoiding a duplication of plants and their organization of employees.

By the second plan, the sewers leading to the disposal plant would be adequate for the 1940 population and could therefore be considered of permanent value, while the two 36″ sewers leading to the Jamaica plant would not provide the most satisfactory ultimate lines for delivering to a marginal interceptor. Also, by the second plan, a considerable area lying to each side of the trunk sewers could be made tributary before any more general system is constructed.

From a general consideration of these matters and from the fact that the bay near the outlet from a plant on Stroothoff's Island is very shallow and poorly adapted to the reception of an effluent with only moderate clarification, it is believed that the treatment of all the sewage under consideration at the site of the present Jamaica plant is preferable.

7. Conclusions.—I would therefore suggest as desirable:

1. That the sewerage of that part of Queens draining to the north shore of Jamaica bay be developed so far as possible on the separate system.

2. That the sewerage system of Jamaica be reconstructed only where the present sewers are of inadequate size or depth for the estimated population of 1940, utilizing in particular much of the minimum size of sewer (8″) now being used.

3. That where combined sewers are adopted all excess during storms over the maximum estimated sanitary flow for 1940 be diverted at suitable points to storm drains.

4. That all such storm drains be provided with sand catchers before delivery to Jamaica bay or its tributaries.

5. That the sewage of Jamaica and sewer Districts 40A,
1534 40B and 40C be treated by chemical precipitation at the present plant until some more comprehensive scheme can be availed of.

6. That the construction of the tanks and their operations be so modified, in accordance with the suggestions detailed in Art. 6, as to furnish increased efficiency at less cost.

7. That the supervision of the treatment be instrusted to a chemist or sanitary engineer of technical training as already recommended by Mr. Hering.

Mr. Donald M. Belcher has assisted in securing data, preparing maps and in estimates of cost contained in the above report.

(The report is accompanied by a map showing "Studies for Temporary Sewage Disposal for Woodhaven & Richmond Hill Adequate to 1920, and showing mark I N—1053—III.)

By Mr. O'Sullivan:

Q. Mr. Allen, did you make an inspection of Jamaica Bay, and from the facts and observations that came to your knowledge make a report to the President of the Metropolitan Sewerage Commission?

A. I did.

Q. When did you make such a report?

A. September 30th, 1910.

Q. I ask you to read that report.

Re-cross-examination by Mr. Riker:

Q. Mr. Allen, this report is based upon your own personal inspection of Jamaica Bay?

A. Yes.

Q. And when was your report made with reference to your inspection?

A. Two days later.

Q. How far is Jamaica Bay from Robbins Reef, if you know?

A. Why I should think it was about 8 or 10 miles.

Mr. Riker: I object to the evidence on the ground that it is clearly immaterial and irrelevant as bearing upon the ques-
1535 tions at issue in this cause, and I object on the further ground that it is not a memorandum to refresh the memory of the witness as to observations of facts, what is represented to be a report thereon, and it is not offered as an exhibit, and cannot be used and read into the record.

Mr. McCarter: The same objection.

The Commissioner: Note the objection of Counsel for defendants.

A. (Report dated September 30th, 1910.) I beg to submit the following record of our recent inspection trip in Jamaica Bay.

On Wednesday, September 28, an inspection trip in Jamaica Bay was made by Dr. Soper, Mr. Belcher and myself in the Quadrant II.

Leaving Pier A at about 9:25 we reached Hammels at 11:30 an hour and a quarter after low water, where we secured a pilot. Passing through the draw, we went nearly to the head of the channel south of Horse Island at Arverne. From west of Belle Harbor the shore is well built up and in this channel we noted the outlets of pipe sewers 12 or 15 inches in diameter at six or eight points. Most of these were within a half foot of the water surface. It is probable that nearly every street here is provided with a sewer and an outlet of this kind, so that, although the waterway continues around Horse Island to the bay, the water in this channel was quite polluted.

Between Hammels and Motts point a large sextant of marsh land has been filled in and a considerable length of timber bulkhead constructed. These improvements with the number of new houses on this territory indicate a somewhat rapid development over this area which is over a square mile in extent. Fronting on the bay and with good transit facilities, a rapid growth may be expected here in the near future.

1536 Passing Motts point, we ascended Nigger Bar Channel to within a half a mile of its upper end on the north side of Far Rockaway. The water being too shallow to proceed with the launch, we rowed nearly to the upper end in the tender: In this half mile, the pollution increased, due to the effluent from the Far Rockaway precipitation plant, until the water was practically all precipitated sewage, being light gray and cloudp and with many very fine particles. Coarser solids had been removed by the treatment. Ulva latissima was seen frequently in the water and on the marshes, but was not in an offensive condition. Considerable filling in has recently been done in this vicinity; several rows of small new houses were noted on the south side, and a number of larger isolated ones on the north side of the channel.

Returning we dropped the pilot at Hammels, stopped to make inquiries at the Jamaica Bay Yacht Club and proceed by way of Big Channel to Canarsie. The low marshy island, mostly submerged at high tide, but often containing fishermen's houses, and the tortuous narrow channels were all noted. Numerous oystermen were observed tonging from small boats in Grass Hassock channel, near Ruffle Bar (where a number of men were gathering them while wading) and off Manhattan (?) Beach. The large number of launches at Canarsie indicated the extent to which the waters of that part of the bay are used for pleasure purposes.

Leaving Canarsie at 3 P. M. we passed close to Barren Island, where a north wind furnished abundant evidence of the character of the extensive plants operated there for the reduction of garbage and the disposal of dead animals. The water front on the southeast side of the island is quite well taken up in this way. Beyond there are many smaller buildings, houses for workmen, etc., but it

1537 would appear that the greater part of the island, as well as the greater marsh area lying to the northwest would be available, if desired, for sewage purification works.

We passed Manhattan Beach at 4 P. M. and arrived at the Battery at about 5:25 P. M.

By Mr. O'Sullivan:

Q. Did you make any observations or inspections of the pollution of Jamaica Bay and the improvement basins therefor?

A. I made a report on November 22nd, 1910, on the probable pollution of the basins which are proposed for the Jamaica Bay improvement. They are not built yet. They are planned.

Q. And was that report based on observations that you made of the conditions there and this probable pollution?

A. Partly of conditions there and partly of conditions in similar bdies of water, particularly Newtown Creek and Gowanus Canal.

Q. When did you make the report?

A. November 22nd, 1910.

Q. I ask the witness to read that report.

Recross-examination by Mr. Riker:

Q. Mr. Allen, what are you assuming to be or about to be as the basis of this report?

A. The Jamaica Bay Improvement Commission planned some water front improvements in Jamaica Bay and those were finally adopted by the City and the United States Government. That is the bulkhead line and pierhead line was established by co-operation between those two bodies. Appropriations have been made to begin the work, and the main outlets have been determined on the north side of the Bay. These plans included running along the shore certain canals, running up into the city for from half a mile to two miles in length and it seemed that there might be objectionable pollution of these canals after being constructed, and it
1538 was to form some conception of what the probable condition would be that this investigation and report was made.

Q. And this report was upon a project which has not yet been executed?

A. Yes.

Q. And the data upon which the report is based, outside of this hypothesis of the construction of this work, where did you get the data?

A. It is largely a matter of opinion.

Q. Largely a matter of opinion based on what facts?

A. Based upon sufficient observations in other bodies of water such as the Gowanus Canal, the Newtown Creek.

Q. Facts observed by you?

A. Yes.

Q. And known or not known by you to exist in the waters of Jamaica Bay at that point?

A. They do not exist at the present time.

Q. So that it is an opinion upon a hypothesis, is it?

A. Yes.

Mr. Riker: I object, one more question.

Q. How far is this from the point of the proposed idscharge of the Passaic Valley Sewer?

A. I should say from 9 or 10 to 15 miles.

Mr. Riker: I object to it on the ground that it is entirely irrelevant to the subject matter of this litigation. I object to the reading of this report on the ground that a report unless it is authenticated and offered and admitted as an exhibit cannot be lawfully read into the record.

The Commissioner: Note the objection of Counsel for Defendants.
Mr. McCarter: The same objection.
The Commissioner: Note the objection.

A. (Report dated November 22, 1910.) I beg to report as follows concerning the possible pollution of the basins as at
1539 present proposed by the Dept. of Docks and Ferries in connection with the contemplated Jamaica Bay Improvement. In general the conclusions reached are that fouling of these basins is not likely to be extreme or to cause a septic condition of the water, unless from local conditions which cannot at this time be foreseen. That much filth will find its way to these waters is, however, certain, and the most feasible way to ameliorate the situation would appear to be by widening, shortening, and reducing the depth of the upper part, of each basin.

Report of the Pollution of the Jamaica Bay Improvement Basins.

1. Typical Basin Assumed.—According to the plan of the Jamaica Bay Improvement Commission, as modified by the Department of Docks and Ferries, there are to be long basins 300 or more feet in width running inland from the pierhead line at Sheepshead Bay, Dead Horse Inlet, Island creek, Paerdegat Creek, Fresh creek, Spring creek, Hawtree creek, Bergen creek, Cornell creek, Head of Bay, Nigger Bar and Motts point. For the general purpose of discussion, a typical basin having the mean dimensions of the six extending north from Jamaica Bay beginning with that at Paerdegat creek in the above list has been assumed. Such a typical basin would have the following elements:

Tributary drainage area	5,250 acres
Length of " "	25,000 ft.
" " basin	6,900 ft.
Width " "	370 ft.
Depth of basin at mean low water	18 ft.
" " " " " high "	22.5 ft.
Contents of basin at mean low water	46 m. cu. ft.
" " " " " high water	57.5 " "
Tidal prism	11.5

Based on the above data there result the following deductions:

1540 1. The tidal prism amounts to 25% of the entire contents of the basin at M. L. W. In other words 50% of the low water volume of the basin enters during the two flood tides each day.

2. If the harbor water acted as a piston, it would advance but one-fifth the length of the basin, or 1,380 ft. from the mouth, at each high tide and then recede.

3. The mean velocity due to the tide at the mouth of the basin would be about 4.2 feet per minute—much too small to effect any scouring action.

If the motion of the water were due to the tides only, there would be no progression of the stagnant water at the upper end of the basin toward the bay. Any resultant motion in this direction will be due to the inflow of land water. A rough estimate of this is as follows:

*Mean daily volume of rain falling on the area draining to the basin throughout an ordinary year	2,350,000 cu. ft.
Run-off assumed at 50% of rainfall daily	1,175,000 " "
Run-off reaching head of basin by gutters and drains, assumed as 8/10 of the whole	940,000 " "

From this there follows:

1. The mean daily inflow of land water amounts to about 2% of the low water contents of the basin.

2. If the land water acted as a piston, it would force the basin water about 140 ft. farther down stream each day at low tide.

3. It would take at this rate 49 days to replenish the entire basin with land water.

Nor would the flushing due to severe storms be a factor of very great importance. If we assume a downpour of 2 inches in 6 hours, the run-off would be but about 4,000,000 cu. ft. or less than 9% of the L. W. contents of the basin.

2. General Considerations.—While there would be an in-
1541 flow of some 52% of new water to the typical basin from the tidal action and from run-off from rainfall, the greater part of the basin would be dependent on the diffusion of the new supplies and on the absorption of oxygen from the atmosphere to preserve it in good conditon. Diffusion up stream would be retarded by the comparatively narrow width of the basin as compared with its length, but by currents set up by the wind, by vessels and other agencies, it is probable that there would be found some admixture of harbor water well up toward its upper end.

It is impossible to predict the actual degree of pollution. This will depend on the number and kind of vessels using the basin, and the number of men employed on them, the street dirt brought in by rains, the wastes admitted from factories and those (dead animals, etc.) deliberately thrown into the water.

By an arbitrary assumption, but one that seems reasonable, as to

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* Based on a mean yearly rainfall of 44.7"—Record covering 61 years prior to 1896—Public Water Supplies—Turneaure & Russell, p. 45.

the well oxygenated water admitted and, to a certain extent diffused, each day, we may secure a rough conception of the admissible pollution. I have assumed that 900,000 cu. ft. land water plus 25% of 23,000,000 cu. ft. harbor water equals 6,650,000 cu. ft. per day or 77 cu. ft. sec. might be counted on for the disposal of sanitary sewage. If 25% should be considered too high or too low, the general argument would remain the same.

It has been stated that from 25 to 30 dilutions will render Milwaukee's sewage inoffensive. At that rate the typical basin might dispose of 266,000 to 222,000 cu. ft. or from 2 to 1.7 Mgd. of sewage per day, equivalent, at 125 gals. per cap. to that from a population of from 16 to 13½ thousand persons.

*Mr. Rudolph Hering mentions a diluiton of 3 cu. ft. sec.
1542 as satisfactory for the sewage of 1,000 persons. At that rate the basin would take the sewage from a population of 25½ thousand.

Mr. F. P. Stearns** states that 8 cu. ft. sec. will dispose of the sewage from 1,000 persons without offense. At that rate, 10½ thousand might drain to the basin.

These estimates of course presuppose proper dispersion of the impurities discharged into the basin.

3. Preventive measures desirable.—It hardly seems probable that with the diversion of domestic wastes from the land, with the interception of gross impurities by sand catchers in storm drains and with ordinary efficient policing, the amount of the impurities reaching the basin would approach in amount the least of the above figures, equivalent to the sewerage of over 10,000 persons. Nevertheless it is quite possible that the condition of some of the basins as planned would become objectionably foul at points of maximum pollution during periods of drought. As already mentioned, the extent of such local or temporary nuisances cannot be foretold, but it would be well to minimize the degree of pollution as far as practicable. The most obvious of these means would be:

a. Flushing the basin by pumping to or from its head.

b. Flushing the basin at low water by discharge through a lock.

c. Flushing the basin by intermittent discharge from a reservoir.

d. Promoting diffusion by adopting a different form of basin—wider and shorter—similar to the Atlantic, Pacific and Erie Basins.

e. Promoting diffusion by a relative increase of the tidal prism near the upper end.

Flushing by pumping—would be effective. but costly. It
1543 is a method that could be easily adopted if the necessity developed, but could at least be referred for some years.

Flushing by the sudden release of the tital prism through a lock need not be considered on account of the interference with navigation and the great cost.

Flushing from a storage reservoir may also be dismissed as the construction of such a reservoir would be costly and would require

*Engineering Record, March 10, 1888.

**Rep. Mass. State Board of Health, 1890.

land that would otherwise be available for purposes of manufacture or commerce.

The adoption of a wide, open basin would permit of a more general movement of the water due to the influences the tides and wind, but would not provide for any permanent current, especially in places far from a direct line between storm water outlets and the entrance to the basin. It would involve a radical departure from the plans already formulated, would be less economical of space and probably less desirable in the solution of transportation problems. It would also involve a longer carriage for storm water on flat territory. But without adopting any such extreme alteration in design, it might still be possible to effect an improvement by shortening and widening the basin.

Provision for a relative increase for the tidal prism may be had without any radical change in the proposed plan except a diminution of the depth at the upper end. If, for instance, the depth at low water were reduced to 12 feet, the volume would be increased $4.5 = 37\frac{1}{2}\%$ instead of 25% with a depth of 18 ft. and the two

12

daily tides would bring in 75% instead of 50% of the low water volume to aid in dilution. This would not be necessary at the lower end, where there would be in any case a free admixture of harbor water, and as the larger vessels would presumably dock near the bay, any reduction in depth would be inadmissible. But,

1544

if, say, the upper half of the basin were reduced in depth as indicated, there would follow not only a much more effective dilution of this part from the harbor water, but the progression of land water toward the bay would be correspondingly increased and the depth would be sufficient for light draught coasting vessels, tugs, lighters, and scows.

4. Conclusions.—Without full knowledge of the necessities of navigation and land transportation as well as of future conditions as to pollution, I do not feel that final recommendations can be made, but would suggest as follows:

1. That before commitment to any plan, the design of the basin be reviewed to ascertain to what extent they may be shortened and widened and their upper ends reduced in depth, having due regard to economy of construction, the ultimate demands of commerce and of storm drainage.

2. That in any plan adopted, the possible future desirability of flushing by pumping be borne in mind.

In the studies involved in preparing the above report, I have been assisted by Mr. D. M. Belcher.

(The report is accompanied by a map showing "Jamaica Bay Division Location of Disposal Plant, on Jo Co's Marsh, and showing mark I N-1061-III, dated Dec. 1, 1910.)

By Mr. O'Sullivan:

Q. Mr. Allen, is Jamaica Bay a part of the waters of New York Harbor? A. It is.

Mr. Riker: Have you finished with that?
Mr. O'Sullivan: Yes, sir.

Recross-examination by Mr. Riker:

Q. Mr. Allen, have you from your own observations and your own knowledge observed the facts which would justify you in saying that the discharge of sewage at Robbins Reef at a depth of 40 feet would enter in any way or affect in any way Jamaica Bay?
1545 A. Not appreciably.
Q. Will it at all from anything that you know?
A. I think it would to a very slight degree.
Q. In what way?
A. The water passing out of the Narrows would probably pass down and go into Jamaica Bay on the return tide.
Q. Have you traced any such float, has any float observation or other fact within your knowledge indicated such a conclusion?
A. No.

Mr. Riker: I renew my objection to this report on the ground that it is irrelevant.
The Commissioner: Note the objection.

Redirect examination by Mr. O'Sullivan:

Q. Did you make any observations under the direction of the Metropolitan Sewerage Commission on the sewerage of Jamacia Bay Division, inspection trip over the line of interceptors?
A. I did.
Q. And from the facts alleged, did you submit a report to the Metropolitan Sewerage Commission?
A. I did.
Q. In the discharge of your duties?
A. I did submit a report.
Q. And on that one topic?
A. On the sewerage of Jamaica Bay, yes. There was only one, an inspection.
Q. When was that?
A. January 25th, 1911.
Q. I ask the witness to state the contents of that report.

Recross-examination by Mr. Riker:

Q. What is this report based on so far as the data is concerned?
A. On a trip made over the line of the proposed interceptors near the shore of Jamaica Bay.
Q. Does the report deal with the expected results of the interceptors?
A. It deals particularly with the practicability of constructing the interceptors and the cost.
1546 Q. Is it or is it not a report on the method on the part of one of the municipal corporations of the Complainants to remove its own pollution from Jamaica Bay?

A. Yes, it has to do with that subject.
Q. Has it been done?
A. No.

Mr. Riker: I object to the report going into the record on the ground that it is a statement of opinion upon a hypothesis merely, and upon no facts, and that it is immaterial and irrelevant to this suit by reason first, of the location of the plant, the proposed location of the plant, and second by reason of the subject matter of the investigation, and I object to it further on the ground that the report cannot be read into record until it has been properly authenticated and offered and admitted as an exhibit.

Mr. McCarter: The same objection.

The Commissioner: Note the objection of Counsel for Defendants.

Jamaica Bay Division Memorandum of Inspection Trip Over Lines of Interceptors.

Jan. 25, 1911.

Started with Mr. D. M. Belcher in automobile from Flatbush Ave. Station and went through Flatbush, noting the state of development, to Shellbank Creek Disposal Plant. At this plant there was no appreciable odor, possibly due to an excess of lime and chlorine used. The sewage is weak and effluent clear. The general condition of the place was clean. Sludge is pumped at intervals of several weeks, in winter, to adjoining beds and when dry is used for filling. More or less surface water is admitted by catch basins to the sewers. The sewage is received and the effluent passes to Shellbank Creek through 24" pipes.

About 1½ mgd. are ordinarily pumped and this is not greatly
1547 increased in summer.

From this point the route lay by Kings Highway, East New York and Old South Road and Rockaway Road to Far Rockaway. At the several streams crossed by Rockaway Road, measurements were made of the width and depth, as follows:

Stream.	Width.	Depth about low tide.	Water surface below bridge floor.
Hassock Creek	33′	2′	8′
Drovers	36′	3′	5′
Hook Creek	50′	11′	9′
Hook Creek Branch	115′	3′	9′
Mott Creek	63′	5′	9′

This information, although approximate only, is valuable as determining the necessity and number of siphons that will be required.

After lunch at Far Rockaway, Norton's Creek was inspected and a depth of 15½ feet noted. A drawbridge about 110 feet long spans the creek. The necessity of this is not apparent, as there can be no

amount of shipping between this and the railway bridge 200 or 300 ft. to the south.

The return trip was by way of Lawrence, Woodmere, Valley Stream, Springland, Jamaica, Richmond Hill, Woodside, Eastern Boulevard, Bedford Ave. and Williamsburg Bridge to Astor Square, arriving about 3:40. The topography and development along the route were especially noted.

Redirect examination by Mr. O'Sullivan:

Q. Did you make in the discharge of your duties as Engineer for the Metropolitan Sewerage Commission, did you make any studies of the prospective relative development of the area tributary to Jamaica Bay?

A. I did.

Q. With a view to determining what facts?

A. Determining the capacity required for the disposal of the sewage from that district; the capacity of the sewers and of the disposal plant and also the character of the disposal that would be most suitable. That was made on August 3rd, 1911.

1548 Q. Were these facts collected and your computations made after you had acquired knowledge through observation of the polluted condition of Jamaica Bay?

A. They were.

Q. Did this report deal with the prospective added pollution that an increase in the population through development would discharge into that bay?

A. It did, but that was rather secondary. The principal object of the report was to form a conception of the probable increase in population with a view of the proposed collection and disposal of the sewage. The whole subject, rather than the pollution of the waters. It was more for the construction of the sewers and the disposal plants. It was largely a matter of forecast as to population and distribution.

Q. And dealing with the possible capacity of the waters of Jamaica Bay to stand the added pollution?

A. It had not directly very much connection with that, the report.

Q. What did the report consider chiefly?

A. It dealt principally with the prospective development depending largely on the Long Island Railroad Improvement and the proposed Jamaica Bay Improvement, which would increase the density of population, which of course would have a bearing on the pollution of the bay, but the immediate object was the design of a system for collecting and disposing of the sewage.

Q. You made the report yourself?

A. I did.

Q. The language of the report is your language?

A. Yes.

Q. And the facts observed are the facts that you fashioned in that report?

A. Yes.

Q. I ask the witness to give that report on the record.

Recross-examination by Mr. Riker:

Q. Mr. Allen, the data on which this report is based and which are stated in the report did you collect them personally?

A. Yes, sir.

Q. From what sources?

1549 A. I got opinions from various individuals, some in a private capacity and some public officials as to the probable development of that territory and the population statistics are based largely upon census returns, modified in the future by the opinions of those gentlemen.

Q. And were these opinions and data directed to some prospective work in the work of sewage interception or disposal?

A. The opinions of these gentlemen you mean?

Q. Yes.

A. Upon the facts that are purported to be embraced in this report, are the opinions of some gentlemen and some things obtained.

Q. From the census reports?

A. Yes.

Q. And your own opinion on these opinions?

A. Yes.

Mr. Riker: I object to reading this report into the record for the same reasons that were offered as to the last report, and also for the further reason that this appears to be merely an opinion upon an opinion.

Mr. McCarter: The same objection.

The Commissioner: Note the objections.

The Witness: If you will allow me to say a word. When you say my opinion is based on their opinion. Their opinion had nothing to do with the future figures that I adopted. That is I had to base my opinion on the opinion received from these men. I had to form my own conclusions as to the combined opinion of the different authorities that I consulted.

(Report dated August 3rd, 1911.) I beg to report as follows regarding the proposed scheme for the improvement of Jamaica Bay and the probable development of the adjacent territory upon which plans for the future sewerage of this district ultimately depend.

1550 **Proposed Plan.**

The plan which has been proposed by the City and agreed to, so far as it is concerned, by the War Department, consists in dredging and maintaining a channel from the ocean through Rockaway inlet and around the shores of the bay. From this channel basins or canals for the accommodation of shipping would extend inland for varying distances. These basins and the pierhead and bulkhead lines, as finally established by the Department of Docks and Ferries and approved by the Secretary of War, May 1, 1911, are shown on drawing S—1149—III.

The plan includes the construction of bulkheads and piers and the

g in of marsh and other low lands behind bulkhead walls. e aggregate, exclusive of the islands of the bay, some 8,500 that may be reclaimed. The population tributary to the bay, ated by the Jamaica Bay Commission for the year 1950, follows:

Ward.	Density.	Population.
Brooklyn	74	420,000
29th, Brooklyn	99	187,500
Brooklyn	23	190,000
1th, Queens	31	480,000
Total		1,277,500

Cost of the Work.

e ultimate cost to the City of the improvement carried from the east corner of Barren Island to a point about 7,000 ft. east of ong Island Railway trestle crossing the bay is estimated by the Engineer of the Board of Estimate at from $67,600,000 to 70,000 depending on the type of bulkhead adopted. To this d be added the cost to the Government, estimated by Col. D. W. wood, Corps of Engineers, at $7,430,050, or a total of about 00,000. These estimates provide for channels 30 feet in depth ,500 feet in width, to maintain which will require the estimated sum of $55,600 annually.

Before being committed to this large expenditure, a moderate sum will be used to begin the work. The U. S. Government has made an appropriation of $250,500 to provide an entire channel 18 feet in depth and 500 feet wide. On the part of York City a sum not exceeding $950,000 has been appropriated thorization of the Board of Estimate and Apportionment, Feb. 911, to be expended as follows:

r bulkhead, sand dyke and rip-rap walls to retain the aterial dredged between Spring Creek Basin and the rmination of the bulkhead at the point of Barren land	$50,000
r dredging the main channel in Jamaica Bay between Spring Creek Basin and the southeast point of rren Island, contingent on the execution of a contract th the U. S. Government by which all or a portion of is cost can be reimbursed to the City	150,000
r the acquisition of lands located in or on Jamaica y for filling which lands shall be determined by the mmissioner of Docks in conjunction with the Commissioner of Sinking Fund	750,000

ith regard to Article 2, the U. S. Government has agreed to rse the City to the extent of 8 cents per cubic yard required for ing about 4 miles of main channel in the bay.

Plan of Development.

The Jamaica Bay Commission offered two general plans of development. The majority report recommended an intensive development at one or two selected points in order to demonstrate the advantages of the general improvement and to provide nuclei which would expand and prove of economic value from the start. The minority report recommended the acquisition of large tracts of marginal lands which can be secured now at much less cost than later, after which growth will proceed on natural lines and at a much less ultimate cost to the City, through appreciation in value of the land so secured, than by any other plan.

The Department of Docks has prepared two general plans
1552 to present to the Commission of Sinking Fund, one embodying each of the above schemes, and it is probable that one or the other will be adopted in the near future.

The Present Status.

According to Mr. Nelson B. Killmer, former Secretary of the Jamaica Bay Commission, it is probable that the plan of the minority report will be adopted. There are, however, two matters to be settled before proceeding further:

First, the existing transatlantic cable lies between Rockaway Point and Sheepshead Bay and therefore crosses the proposed entrance channel. The cable company are willing to re-locate this from a landing on Rockaway beach to the east of this just as soon as the City grants a franchise for the necessary right of way. This matter will probably be settled in the fall.

Second, before filing the approved plan of bulkhead lines in Jamaica Bay with the Sinking Fund Commission, the rights of the City to certain grants made to the owners of the islands of the bay must be ascertained by the Corporation Counsel. It is contended that these grants were made with the provision that, if required by the City for public purposes, they could be annulled at any time. The owners, on the other hand, take the position that if condemned for such uses, due compensation should be made. This too, Mr. Killmer says, will probably be settled so that the map can be approved by the Sinking Fund Commission in September.

As soon as these two matters are disposed of, there seems to be no reason for further delay in starting the work.

Engineering Difficulties.

In carrying out the improvement there are, however, two possible engineering difficulties: the maintenance of the entrance channel and the prevention of scour at Barren Island.

1553 Mr. P. P. Farley, former President of the Jamaica Bay Improvement Commission, states that for many years, in spite of the rapid extension of Rockaway point, the main currents and channel have retained a direction easterly of south—never westerly. [x] Therefore, if, as has been proposed, the channel should be

[x] See Rep. Jamaica Bay Improvement Comm. 1907, Pl. II.

dredged in a southwesterly direction, the cross-currents from N. Y. Upper bay would continually cause extensive deposits which would be costly to remove. If, however, training walls were constructed in a direction a little to the east of south, the channel would maintain itself.

Mr. W. G. Ford, the minority member of the Jamaica Bay Commission, who is a graduate of Annapolis and has been engaged on considerable coast survey and harbor work, believes there will be no difficulty in maintaining jetties at the entrance, but that even if these were omitted the annual expense of dredging the 1,000,000 cu. yds. that might be expected to deposit there would be but $45,000, and even if this cost $100,000 per annum, it would not be a matter of serious consideration as compared with the objects attained by the improvement.

Mr. H. N. Babcock, Asst. U. S. Engineer, says there is no question but that a channel can be dredged and maintained—it is merely a matter of cost. Nor does he attach great importance to the direction of the entrance as influencing deposits. These, in his opinion, will be the result of hard easterly or southeasterly storms rather than the permanent tidal or littoral currents. The location of the jetties, as proposed by Col. John G. D. Knight, and shown on the accompanying sheet, may not be the best. These provide the shortest channel to deep water, but the plan should receive further
1554 study before adoption. It may be preferable to substitute one curved jetty, concave to the southeast, starting near Plumb Island and ending nearly tangent to the proposed West jetty shown on the plan. This would concentrate the effect of the tidal flow entering and passing out of Rockaway inlet.

In any event the experience gained with the 18 ft. channel will be available before proceeding to execute the final work. In dredging this channel, it is not likely that the dredges now at work on the Ambrose Channel could be used to advantage on account of their draft, which varies from 11½ feet when light to 17 and even 23 feet when loaded.

A further difficulty may lie in the construction of a permanent bulkhead at the southeastern point of Barren Island, where the channel hugs the shore, where the current is quite rapid and where the shore and bottom are of a shifting nature. These conditions would not, however, be greatly affected by the proposed improvements.

Probable Increase in Population.

Interviews have been held with Mr. C. W. Staniford, Chief Engineer, Department of Docks (July 21), Mr. W. G. Ford, Consulting Engineer (July 21), Mr. P. R. Ferley, Deputy Commissioner of Fire Department, Brooklyn and Queens, (July 29), Mr. Elwin S. Pipe, President, Eagle Savings Bank of Brooklyn (Aug. 1) and Mr. Nelson B. Killmer, former Secretary of the Jamaica Bay Improvement Commission (Aug. 2) on this subject.

Mr. Farley believes that unless the plan is adopted of attempting an intensive development from one or two points, such as the vicin-

ity of Fresh Creek, and that of Canarsie, the development will be slow and disappointing. With this exception he agrees with Messrs. Staniford and Ford that at first there will be a moderate but
1555 sure growth; that the first centers of population will enlarge so that, finally, the built-up areas will merge with those along the main line of the Long Island Railroad to the north.

Mr. Killmer believes that there is already a demand for increased port facilities that can best be met by this improvement. He has had letters from manufacturers who would be glad to establish plants there if shipping accommodations were provided, and he believes that, as with rapid transit, the improvement will induce a very considerable demand for the property which, for some ½ mile from the bulkhead, the City will acquire.

Mr. Killmer is very hopeful that Jamaica bay may become a large canal terminal, and in this connection he heartily approves the plan of constructing a connecting canal from Jamaica bay. According to the most recent plan, which will be presented for its third reading by Senator Burton of Ohio at the next session of Congress, this would run from the upper end of Flushing bay to Cornell creek, instead of Hawtree creek, as formerly proposed, and would in this way avoid all railway crossings but one. This would be provided for by raising the track to elev. 67, as already proposed. The maximum elevation of the divide where crossed would be 95. A sketch attached shows in a general way the proposed line.

Mr. Killmer is evidently keeping very close watch of the progress being made and is optimistic in his anticipation of an extensive development of the shores of Jamaica bay.

Mr. Piper is firmly convinced that after a year or so from the beginning of operations, the growth of the part of the City bordering on Jamaica bay will be very rapid, especially in the line of manufactures. He also believes that in time the canal from Flush-
1556 ing bay to Jamaica bay will be constructed, greatly increasing traffic to and from the latter. Another important factor in the development would be the location of a large canal terminal at this point. This Mr. Piper appears to think is quite likely to come about.

With the advantage of water and rail transportation and inexpensive building sites, it is hoped, and I think anticipated, by these gentlemen that manufacturing establishments will locate here and that the development will attract shippers and dealers in building material and other light domestic cargoes which will be beneficial to those who settle or build in the vicinity of the bay.

Population Provided for in Estimates for Sewerage.

In our estimates for sewerage, we have assumed a total population of New York City in 1940 of 9,000,000, an increase of 89% on the population in 1910.

The population of Brooklyn has been forecast at 3.2 million, an increase of 96% and that of Queens at 870,000, an increase of 206%

over that of 1910. The mean increase per decade would be, therefore, for:

	Density per acre, 1940.	Mean growth per decade.
New York City	325	29.7%
Brooklyn	85	32.0%
Queens	8	68.7%

The reasons for these assumptions are stated in a memorandum by Mr. John H. Gregory, dated October 13, 1910.

The population tributary to Jamaica bay in 1910 was:

	Population.	Density per acre.
Brooklyn	269,875	21.
Queens	80,818	3.5
Nassau Co. (Estimated)	1,783	

1557 The following populations were then arrived at by dividing the two boroughs into drainage districts and assigning populations to each as follows:

Brooklyn $\frac{10.3}{A\ 68}$ $\frac{10.3}{1B45}$

	Density per acre.	Population.
Lower East River	200	1,670,000
New York Bay	76	911,000
Jamaica Bay	35	619,000
		3,200,000

	Density per acre.	Population.
Queens:		
North of Divide	13+	580,000
South of Divide	9.7	290,000
		870,000

tion is not dense at present, but better transportation facilities may

The forecast population from these districts in 1940 has therefore been fixed as follows: $\frac{10.3}{A\ 124}$

Forecast Population Draining to Jamaica Bay—1940.

Area	Population.	Density per acre.	Mean growth per decade.
Brooklyn	619,000	35	76.7%
Queens	290,000	9.7	86.3%
Nassau	91,950	5	.....
	1,000,950	15	

Assuming these estimates as reasonable, these populations were apportioned to the sub-divisions taken by the U. S. Census with the results shown on the accompanying population map 2A-1030-III.

Ultimate population were then determined by assuming maximum densities, shown also on the attached population map 2A-1030-III, resulting in the following totals:

Ultimate Population Draining to Jamaica Bay.

Brooklyn	928,000
Queens	1,530,000
Nassau Co.	276,000
Total	2,734,000

Believing that works of the magnitude and character proposed should not, in the case of Brooklyn, where conditions are pretty well established and can be forecast with some degree of reliability, be planned for an earlier date, population densities were assumed for the year 1960 as follows:

1558

Population Densities—Brooklyn, 1960.

Census District	1	2	3	4	5	6
Density per Acre	27	22	65	70	40	90

In the case of Queens, the future is more uncertain. The population is not dense at present, but better transportation facilities may induce a large increase in the future. In view of those facts, and to avoid a heavy expenditure that may later be found unwarranted, 1950 has seemed a more reasonable date to provide for. In the case of Queens if the demand exceeded the capacity of the interceptors, these could be relieved more readily by subsidiary radiating lines than the main interceptor in Brooklyn. Population densities for Queens were therefore assumed as follows:

Population Densities—Queens, 1950.

Census District	7	8	9	10	11	12-*a*	12-*b*	13
	40	35	25	10	8	8	12	8

The density for Nassau County in 1950 was assumed as 7 per acre.

The densities for 1960 (Brooklyn) and 1950 (Queens & Nassau Co.) have been the basis of our calculations for sewage flow in Projects K, L, M and Z.

Densities of Population in Census Districts as Forecast for Different Periods.

Brooklyn.

	1910.	1940.	1950.	1960.	Ultimate.
1	4	21	..	27	30
2	4	15	..	22	30
3	24	62	..	65	70
4	58	65	..	70	75
5	23	32	..	40	49
6	30	70	..	90	105

1559

Queens.

	1910.	1940.	1950.	1960.	Ultimate.
7	10	28	40	..	90
8	8	24	35	..	82
9	5	17	25	..	69
10	0.9	7	10	..	46
11	0.7	5	8	..	35
12A	0.1	2	8	..	58
12B	3	8	12	..	29
13	..	2	8	..	29
Nassau Co...	..	5	7	..	15

(The report was accompanied by two blue prints.)

Q. Mr. Allen did you subsequently acquire knowledge of facts that enabled you to submit a report that you were directed to submit by the Metropolitan Sewerage Commission on the probable development of Jamaica Bay, with a view to determining the capacity of Jamaica Bay waters to sustain the added pollution?

A. I did.

Q. When did you make that report?

A. That is not dated. It was made during this last year. I presume that there was a letter of transmittal with it, and that I have not in my book.

Q. Can you get the date of that report and submit it later?

A. I should say it was about in August.

Q. 1911?

A. 1911.

Q. Can you later fix the date accurately?

A. I think I can.

Q. I ask the witness to read that report.

Recross-examination by Mr. Riker:

Q. Mr. Allen, what is this report directed at?

A. At the most advantageous way of approaching the subject of constructing sewers for that district. The point was this that sewerage conditions there are very urgent. The population is increas-

ing rapidly, and the present disposal plants are inadequate and the bay is polluted more and more. The plan that we drew up for relieving that situation is rather comprehensive and costly, and would take too long to build to afford any immediate relief and it seemed
1560 desirable to suggest some procedure of relieving the situation.

Q. Then this represents an official suggestion as to the improvements in that direction?

A. Yes.

Q. Authorized in any way by law, or only suggested by your commission?

A. Only suggested by the commission or by myself. It has not been approved by the commission.

Q. Not even approved by the commission?

A. Not that I know of.

Q. By whom were you commissioned to make those suggestions?

A. By the Metropolitan Sewerage Commission.

Q. Not by the municipal government involved, located in the Jamaica Bay territory?

A. No.

Q. Where did you get the data on which the report, which has now been offered to be read into the record, is based?

A. Largely from the sewerage bureaus of Queens and Brooklyn.

Q. Any facts that were discovered from the Census Reports were they used as data?

A. The population forecasts were all based on census reports.

Q. Were there opinions of others used as data for your report?

A. Not that I remember.

Mr. Riker: The reading of the report is objected to for the reasons urged against the last report, and also that it appears to be an opinion on opinions.

The Commissioner: Note the objection.

Mr. McCarter: The same objection.

The Commissioner: Note the objection.

Redirect examination by Mr. O'Sullivan:

Q. Mr. Allen, is it or is it not the chief function of the Metropolitan Sewerage Commission to design a sewerage system for the disposal of the sewage of the Greater City of New York, and to co-operate with the State of New Jersey in solving the problem
1561 that concerns both territories in the given metropolitan area?

A. It is.

Mr. Riker: I object on the ground that this witness is not qualified as an expert on the law. He cannot be asked legally what the purpose and effect of the appointment of this commission is.

The Commissioner: Note the objection.

Mr. O'Sullivan: The question is pressed for the reason that it is in line with this witness' duties, it is the witness' investigation that he is submitting and his observations in the form of a report.

The Witness: In its general features, as I understand it; in its

large features; in the general and collection and disposal of the sewage.

Q. And you submitted these reports with a view to solving the sewage problem of this great city, and prior to the Metropolitan Commission, as a Sewerage Commission, issuing these reports, you had submitted reports to them, and this is the report that I am asking you about?

A. Yes.

Q. I ask the witness to read that report on the record.

A. *Probable Development of Jamaica Bay Drainage Area.*

That the development of the area draining to Jamaica bay will be rapid will probably not be disputed. The chief causes for this are, first, the improvements recently made, and those in contemplation, by the Long Island Railroad Co. and by the Brooklyn Rapid Transit Co. Jamaica is probably destined to be of considerable local importance as the focus of railroad lines to all parts of Long Island: to the west by the Pennsylvania tunnels and to New England by the projected bridge across the East River near Hell Gate, and already large sums have been appropriated by improvements in this vicinity. The effect of this will be felt all along the main line
1562 of the road which extends east and west near the northern limit of this area. The rapid transit lines with the southern branches of the Long Island Railroad will afford quick transportation from nearly all points in the drainage area to Brooklyn and New York. Secondly, the projected Jamaica Bay Improvement, already mentioned, will provide economical entrance for coastwise and inland shipping. Building material can be delivered by water at low cost, stimulating improvements on large areas accessible to the water front, but which are now occupied and of little value.

In this connection, it has been proposed to establish a barge canal terminal in Jamaica bay. The length of water front and the large marginal areas available are not readily found elsewhere. The exposed passage from Norton point to Rockaway point could be obviated by the construction of the Gravesend Ship Canal, which, it is understood, is included in the adopted lay-out for this section of Brooklyn by the city authorities.

Bearing the above facts in mind, it has been assumed that in the distant future the population tributary to Jamaica bay may increase—

In Brooklyn from	282,875	to	928,000
" Queens "	80,818	"	1,530,000
" Nassau County	.....	"	276,000
Making a total of	.....		2,734,000

In planning for the sewerage of this district, it has not seemed best to anticipate conditions more than 40 or 50 years in advance, as influences may arise in the meantime, resulting in an increase or shifting of population quite different from any that can be foreseen

at this time. Material variations from forecast populations are most to be expected in the case of thinly populated and rapidly improving areas than in those where, as in much of the Brooklyn area,
1563 populations are dense and general conditions affecting growth well established. For this reason, estimates for sewerage have been based upon the population in Brooklyn as forecast for 1960, while in Queens and Nassau County-, the populations as forecast for 1950 have been used. These are for the area lying in—

Brooklyn	884,100
Queens	535,700
Nassau Co.	128,700
Total population planned for	1,548,500

General Outline of Proposed Sewerage Project.

The outline of the plan as worked out is, briefly, as follows:

The sewage is collected, so far as possible, on the separate system, and, where this is not feasible, it is confined to the dry weather flow. Allowance is made for a certain unavoidable inflow of ground water.

Where the sewers have been constructed on the combined plan, it is proposed to intercept the dry weather flow only by providing storm water overflows above the points of interception. In this way it is true that a certain amount of house sewage mixed with the storm water will pass to the bay during storms, but the amount entering in this way will be so small in comparison with the diluting water, that no objectionable conditions are to be apprehended from this cause.

A more serious consideration is the street filth and grit carried down with the surface water to pollute and form deposits in the bay. The dissolved organic matter will be taken care of by the large volume with which it will be diluted, but the floating solids and grit should be removed by screening and grit chambers placed near the outlets of the more important storm water drains. The cost operation of treatment at Barren Island and Jo Cos March will,
1564 therefore, be restricted to domestic sewage, with such manufacturing wastes as it may be found best to admit into the sewers.

The entire area is divided into two districts, each having its district system of collection and disposal.

The larger of these will collect all the sewage from a population of 1,192,000, located on the 49 sq. miles lying north of Jamaica bay and west of Cornell creek and on the west including Coney Island and Ulmer Park. This is expected to amount to as much as 166 million gallons per day by 1960 and will be delivered at a pumping station located near Flatbush Avenue and Avenue X. From this point it will be pumped through force mains to Barren Island, where it will be treated and the effluent discharged through submerged outlets into Rockaway inlet.

The 65 million gallons of sewage collected daily from a popula-

tion of 356,000 on the 56 square miles of Queens and Nassau Co. lying to the southeast of Cornell creek will be carried to a pumping station near the bulkhead line at the head of the bay west of Inwood. At Inwood the flow will be increased by the sewage received by a collecting sewer running easterly through the Rockaway peninsula and northeasterly through Far Rockaway. From the pumping station the entire volume will be pumped through submerged mains to a treatment plant on Jo Cos Marsh and discharged into Broad channel.

General Data.

Total area covered	105 sq. mi.
" population served	1,548,000
" sewage per day	231 million gallons.
" estimated cost of construction	$16,367,000
" estimated annual charges	$1,332,600

System with Treatment at Barren Island.

As planned, this starts with a diameter of 5′ 4″ in the Old
1565 South Road north of the present Jamaica disposal works, where it passes under the sewer from Jamaica, intercepting the sewage from that district. The sewage from the low-lying area to the south would be collected at the present disposal works, which would then be converted into a pumping station, and pumped into the interceptor. At Panama St. it passes under the Panama St. sewers; then under the Brooklyn Aqueduct, the location of which controls the elevation of the interceptor. At the borough line and Cozine St., the diameter is 8′ 6″. In Vandalia Ave., just south of the East New York Disposal Plant, the sewage collected at that point is lifted into the interceptor. Assuming that Fresh creek will be dredged for purposes of navigation, it will be best to cross under this by a siphon rather than carry the interceptor by a long detour around the head of the proposed basin. At the head of Paerdegat basin, as well as at Hendrix St., the existing storm drains will pass over without interfering with the flow by depressing the arch of the interceptor, but the domestic sewage collecting at this point will have to be pumped a few feet into the interceptor. On Avenue T, between Ralph St. and Flatbush Ave., the diameter is 14′ 4″ and the invert is about 16′ below mean tide level.

At Avenue V and 11th St., Bensonhurst, a pumping station is being built to pump the sewage of the neighborhood to the 92nd St. outlet near the Narrows. The sewer leading to this outlet will eventually be too small and it is proposed to divert this sewage, when the time comes, to the East through sewers increasing from 4′ 0″ to 7′ 3″ diameter meeting the interceptor from Jamaica at Flatbush Ave. The Coney Island sewage disposal plants would be abandoned or utilized as pumping stations, delivering sewage to pumps to be
1566 installed at Ocean Parkway, near Avenue W, and the sewage delivered to the pumps at the present Shellbank creek plant pumped to the interceptor.

From Avenue T the sewage flows through twin sewers about 10′ 3″ square to the main pumping station where centrifugal pumps of capacity to lift 350 million gallons per day 35 feet will be installed. This is the only pumping station required on the line of the interceptors. Two 7′ 2″ force mains of either reinforced concrete or wood stave pipe then convey the sewage to the disposal plant at Barren Island.

Barren Island has been selected as a most suitable point at which to treat and dispose of the sewage. The area is ample; the land belongs to the City, garbage reduction works are already located there; there are no residences in the vicinity except for the workmen employed at the reduction plant; it is of suitable elevation and believed to furnish, below the surface mud, a good material for foundations; it is accessible to transportation by water, and, on the south, forms one shore of Rockaway inlet, which, on account of its depth, swift currents and proximity to the ocean, furnishes an admirable body of water into which to discharge the effluent.

The degree of purification that will be required is not, at this time, known. A rough computation indicates that if all the sewage naturally draining to Jamaica bay were thoroughly diffused therein, the sewage would ordinarily be diluted by about 178 volumes of water at the time of low water, or nine times the amount required to provide sufficient oxygen to digest the organic matter during the most unfavorable months of the year—those of summer. As this ideal condition cannot obtain, treatment to remove the grosser solids and a certain part of the dissolved impurities should be pro-
1567 vided. For present purposes, in order to be on the safe side, clarification by Emscher tanks and further treatment by sprinkling filters and settling basins has been assumed in the estimates. For the entire plant about 100 acres of land would be required.

The effluent from the plant would flow through four submerged pipe lines and discharge in the deep water of Rockaway inlet. The inoffensive sludge from the Emscher tanks could be used for many years in filling in marsh lands near the plant or, if preferred, dumped at sea.

The estimated cost of construction of this system is as follows:

Interceptors	75,450	lin.	ft.	$4,321,660
Siphons	1,150	"	"	77,500
Pumping Stations	5			755,600
Force Mains	9,400	"	"	356,200
Treatment Plant				4,623,100
Outfall Pipes	750	"	"	152,900
Contingencies	15%			1,543,040
Total Cost				$11,830,000

This large sum would not be expended at first. The construction of certain parts of pumping plants, siphons, treatment plant and outlet pipes could be deferred for many years. But those portions

built should be in accordance with the complete plan, so far as practicable.

The area now draining to Paerdegat and the 26th Ward and Jamaica disposal plants require relief at this time. This will probably have to be met in part by temporary methods, but it is desirable that plans for this eastern portion of the interceptor leading to Barren Island be prepared and the work constructed at the earliest opportunity.

System with Treatment at Jo Cos Marsh.

The east side interceptor begins at a point between Valley Stream, and Hewlett with a diameter of 7′ 3″ and runs in a southwesterly direction to the main pumping station on what is now known as Grass Hassock, where the diameter is 9′ 10″. Sewage from
1568 the low-lying areas around Hook creek, to the north, would in the future be collected at a pumping station near the mouth of Mott creek and pumped into the interceptor.

The Rockaway collecting sewer starts at Belle Harbor with a diameter of 24″, is pumped at stations located at Hammels and Nortons creek, crosses Far Rockaway to the present disposal plant by a 36″ force main and thence flows by a gravity in a sewer 3′ 9″ in diameter to join the East Side interceptor near Inwood.

The main pumping station is provided with centrifugal pumps of capacity to lift 150 million gallons per day 31 feet. Two force mains 4′ 6″ in diameter convey the sewage under the proposed channel at the water front and across Jo Cos Marsh to the disposal plant.

This location has been selected for treatment, as it is at present waste land centrally located with reference to the drainage area. It is at the same time a good distance from improved property while adjacent to the junction of Hassock creek and Broad channel which provides as favorable conditions for dilution as are to be had at the upper end of the bay. The currents depend mainly, however, upon the wind and the oscillation of the tide and are not sufficient to dispose of a large volume of putrescible sewage. The latter will therefore be given a thorough treatment by Emscher tanks, sprinkling filters and settling basins covering in all about 40 acres of ground.

The effluent will be conveyed by two outlet pipes 54″ in diameter, one to Hassock creek and one to Broad channel. The sludge can be used in filling marsh land or dumped at sea.

The estimated cost of construction of this system is as follows:

1569

Interceptors	51,400 lin. ft.	$1,425,600
Siphons		
Pumping stations	4	342,600
Force mains	11,150 " "	263,000
Treatment plant		1,810,250
Outfall pipes	1,600 " "	103,600
Contingencies	15%	591,950
Total cost		$4,537,000

Much of this cost can be deferred for an indefinite time, but such portions as are necessary to care for the sewage of Rockaway and Far Rockaway should be provided at an early date.

Summary.

The following is a summary of the more important data concerning the proposed sewage of the Jamaica Bay territory.

	To Barren Island.	To Jo Coe Marsh.	Total.
Area drained, acres	31,531	35,721	67,252
Population served	1,192,400	356,100	1,548,500
Mean volume of sewage Million gals. daily	166	65	231
Cost of works	$11,830,000	$4,537,000	$16,367,000
Annual charges, including interest at 4½% and sinking fund for 50 years			$1,332,600

Redirect examination by Mr. O'Sullivan:

Q. Mr. Allen, did you by direction of the Metropolitan Sewerage Commission make an inspection of the Bronx Valley Sewer outlet?
A. I did.
Q. And from your observations and inspections did you submit a report for the guidance of that commission?
A. I did, May 19th, 1911.
Q. I ask the witness to state the contents of that report.

Recross-examination by Mr. Riker:

Q. Mr. Allen, what are the data contained in this report?
A. It was soon after the outlet was built and put into use,
1570 the inspectors made it to see what the effect of the discharge was in appearance.
Q. And were these observations of facts made by yourself?
A. Yes.
Q. How long before the report was made?
A. The report does not say, within a few days.

Mr. Riker: I object to the reading of the report into the record on the ground that so far as it deals with observations of fact by this witness, it can only be used to refresh the witness' memory and cannot be read into the report, and insofar as it deals with other matters is incompetent, irrelevant and immaterial.

Mr. McCarter: The same objection.

The Commissioner: Note the objection of Counsel for Defendants.

Inspection of Bronx Valley Sewer Outlet.

May 19, 1911.

The effluent was plainly visible rising at two points six feet apart. It was cloudy, grayish brown, full of fine particles, including small pieces of paper and occasional fragments of feces. Particles of a white grease were abundant on the surface.

At about 10:30 A. M. or 2½ hours before local high water the water surface was about 1.7 feet below high water mark. The outlets were about 15 ft. from shore and 45 ft. from the nearest track of the N. Y. C. & H. R. R. R.

A 3 ft. cast iron drain was discharging about 3 cu. ft. sec. of clean water over the line of the sewer and about 10 ft. in from the normal shore line. The effluent flowed with a depth of about a foot to the open water and increased the dilution of the sewage near the shore.

The water as seen from a launch, was visibly polluted for perhaps 200 ft. from the outlet, although the river itself was
1571 quite brown and turbid. By 11 A. M. the flood current seemed stronger and the sewage effluent was carried without any great dispersion up to the bathing establishment of the Leake & Watts Orphan Asylum, several hundred feet to the north. By 11 A. M. the depth near the outlets was found to vary from 3 to 4 feet, although depths of 4 ft. 5 in., 4 ft. 8 in., 4 ft. 9 in. and 7 ft. were noted. These were probably in holes caused by dredging or scour near the outlets.

Redirect examination by Mr. O'Sullivan:

Q. Mr. Allen, did you under the direction of the Metropolitan Sewerage Commission make a report on inspections of the shores of Gravesend Bay; did you make such an inspection with a view to determining matters relating to sewage?

A. I did.

Q. And from your observations during that tour of inspection, did you submit a report to the Metropolitan Sewerage Commission?

A. I did, July 26th, 1911.

Q. State the contents of that report.

Recross-examination by Mr. Riker:

Q. Mr. Allen, these observations were made by you personally?

A. They were.

Q. And does your report deal with anything except matters that were observed by you personally?

A. No.

Q. Does the report contain your conclusions of any kind upon the facts observed by you?

A. Simply the facts themselves, just the observations, my observations.

Mr. Riker: I object to his reading the report into the record as it is only competent, if it is competent at all to refresh the witness' memory. It should not be and it cannot be read into the record, unless it has been made an exhibit in this case.

1572 Mr. McCarter: The same objection.

The Commissioner: Note the objections of Counsel for Defendants.

Re-direct examination by Mr. O'Sullivan:

Q. Proceed.

A. (Report dated July 26th, 1911.) I beg to report as follows regarding an inspection of the shores of Gravesend bay, made by me July 25.

The tide was low and large marginal areas usually submerged were exposed. Much of this was covered with a growth resembling ulva latissima.

A 12-inch terra cotta pipe was *noted* in the vicinity of 23rd Street, but this was evidently not in use for sewage. A small amount of clean water, probably infiltration, was being discharged.

At Bay 38th Street (Ulmer Park Yacht Basin) pier a sewer was discharging on the east side of the pier several hundred feet from the high water shore line. This was of cast iron, about 10" in diameter, and rested on the bottom. At this stage of the tide it was nearly all exposed. The water near the outlet was grossly polluted, contained much paper and had a strong odor of H 2 S. The water was then perhaps 5" or 6" deep. A man employed at the Basin said the stench was at times very objectionable.

At Bay 43rd Street, an iron pipe sewer about 6" in diameter discharges a small amount of sewage about 100 ft. from shore. A man living near by said the odors were bad at times.

The water along the north shore of the bay, being very shallow, was quite roily on account of a strong S. W. wind.

In Coney Island ship canal the water was brown, and roily, but without evidence of sewage pollution. The attendant at the drawbridge said the condition was much worse since the free flow through Sheepshead bay was checked. He knew of no

1573 sewer outlets above the bridge and but one below, that at 22nd St., Coney Island.

Here a sewer about 24" in size was discharging a good stream of light gray sewage which was carried up stream by the flood tide. A new trunk sewer, about 30" in diameter, is

being laid along Neptune Ave., which it seems probable will intercept this discharge, conveying it to Caisson No. 2.

I then continued to Sea Gate, intending to inspect the disposal plant there if there were one, but there is none at this place.

The sewage is discharged to the ocean by an outlet located at the extremity of Norton's Point.

Q. Mr. Allen, did you under direction of the Metropolitan Sewerage Commission conduct a tour of inspection of Barren Island, and from the facts observed and gathered by you, submit a report later to the Metropolitan Sewerage Commission?

A. I did.

Q. On what date?

A. August 15th, 1911.

Q. I ask the witness to read that on the record.

Mr. Riker: The same objection to this offer as to the last.

Mr. McCarter: The same objection.

The Commissioner: Note the objections of Counsel for Defendants.

A. (Report dated August 15th, 1911.) I beg to report as follows regarding a

Trip of Inspection to Barren Island.

August 14, 1911.

A launch was secured at Sheepshead Bay and an attempt made to go around the Northern end of Barren Island by way of Dead Horse Inlet, Deep Creek and Irish and Island Channels,
1574 but the water was so shoal that it was not thought best to proceed very far in Island Channel, especially on a falling tide. We retraced our course to Rockaway Inlet, noting an oyster house on the Eastern bank of Irish Channel, and five or six men oystering in Deep Creek.

We then went to the Eastern end of Barren Island, passing several garbage scows being unloaded. It was noted that the lower end of the conveyor used for handling the garbage projected beyond the side of the scows and that occasional pieces of garbage that had failed to drop from the conveyor at the works would be dislodged at this point and fall into the water. This was undoubtedly the cause of various pieces of garbage—cabbage leaves, etc.,—that were noted on the ebb current as we approached the works.

I landed at the East end of the Island, and by permission of Mr. Blount, the Superintendent, went over the garbage plant. The work appeared to be carefully conducted and there was a freedom from any offensive odors other than those characteristic of fresh garbage and tankage.

The water supply for the Island is from artesian wells at a depth of about 780 feet. Salt water is obtained through suctions passing to the bulkhead. The tank water is discharged after skimming

(pumping) off the grease, perhaps 200 or 300 feet above the plant, through a wooden drain which was submerged when visited.

This effluent is deep reddish-brown and nearly opaque. In volume it might have been discharged from an 8" or 12" pipe. We noted fish jumping between the stream of this effluent and the shore, which the men on the launch said were blue fish. We allowed the launch to drift down-stream with current and could distinguish the reddish hue given to the water by this effluent for 300 or 400 feet.

Along the channel opposite the works bubbles from the bottom were occasionally noted.

1575 On the return to Sheepshead Bay, the water was quite clean, although the ebb had been flowing three or four hours.

(The report is accompanied by a blue print marked "To accompany 'Report on Trip of Inspection to Barren Island Aug. 14, 1911.'")

Redirect examination by Mr. O'Sullivan:

Q. Mr. Allen did you submit a report dealing with projects for sewerage and sewage disposal for the area of drainage of Jamaica Bay?

A. Yes.

Q. On what date?

A. There were several of them on that subject. The first one was on January 3rd, 1911, January 19th, 1911, January 24th, 1911, February 1st, 1911, February 21st, 1911, and one on April 29th, 1911. That is all.

Q. Did you submit in the form of a report the matter that you had collected relative to the project of sewerage and sewage disposal for the area of drainage of Jamaica Bay?

A. I did.

Q. On the dates that you have stated?

A. On the dates I have mentioned.

Q. I ask the witness to read them, to state the contents of the reports.

Recross-examination by Mr. Riker:

Q. These reports deal with what?

A. With projects for sewerage. The drainage of the area draining into Jamaica Bay.

Q. A project devised by you?

A. Yes.

Q. Has it been adopted?

A. No, not officially.

Q. It is therefore not in the course of construction?

A. No.

Q. It is projected work?

A. Yes.

Q. Does the report deal with any other project than that
1576 that you have already testified to? Any other unadopted project?

A. Not that I know of.

Q. Does it contain any observations of facts made by you?

A. No.

Q. Do these reports,—there are several of them?

A. Yes, several.

Mr. Riker: The reading of the reports is objected to on the same grounds that were urged against the last report.

The Commissioner: Note the objection of Counsel for defendants.

Mr. O'Sullivan: Proceed, state the contents of those reports.

A. This report is dated January 3rd, 1911.

I beg to hand you with this approximate plans and estimates for the year 1940, as follows:

(*a*) Project H—Jamaica Bay Division, comprising treatment with sedimentation tanks and sprinkling filters near Inwood on Barren Island.

Construction		$9,890,000
Annual Cost—		
Int. and sinking fund, 50 yrs. 4½%	$500,400	
Maintenance	424,200	
		924,600

(*b*) Project U—Jamaica Bay Division comprising screening on Rockaway Point and discharge in the ocean.

Construction		$8,182,000
Annual Cost—		
Int. and sinking fund, 50 yrs. 4½%	$414,000	
Maintenance	336,000	
		750,000

1577 *Jamaica Bay Division*

Preliminary Estimate—Project H.

	To disposal at Rockaway Inlet.	To disposal near Jo Co's Marsh.
Interceptors	$1,823,000	$661,700
Siphons	51,000	7,300
Pumping Stations	472,000	208,000
Force Mains	600,000	261,800
Treatment Works	3,110,000	1,130,000
Outfall Sewers	153,000	122,000
	6,209,000	2,390,800
Contingencies about 15%	931,000	359,200
Total	7,140,000	2,750,000
Grand Total		$9,890,000

(The report is accompanied by a blue print entitled "Jamaica Bay Division, Preliminary Estimate, Project H, blue print entitled "Jamaica Bay Division, Preliminary Estimate Project I, map entitled "Jamaica Bay Division, Location of Screening Plant on Rockaway Point and Ocean Outlet," showing mark I M 1059 III, map entitled "Jamaica Bay Division, Profile of Outfall Sewer from Barren Island to Ocean Outlets," showing mark I M-1060-III, map entitled "Jamaica Bay Division, Study of Design for Coffer Dam to be used in the Construction of an Ocean Outlet Project G" showing mark I L-1067-III.)

Report Dated January 19, 1911.

I beg to hand you with this approximate plans and estimates for the year 1940, as follows:

Project J—Jamaica Bay Division, a revision of Project H, substituting Emscher tanks and fine screens for sprinkling filters
1578 at the Barren Island Plant

Construction		$7,192,000
Annual Cost—		
Interest at 4½ and sinking fund 50 yrs. 5.06%	$363,915	
Maintenance	412,585	
		$776,500

(The report is accompanied by a blue print entitled "Jamaica Bay Division, project J preliminary Estimate," a blue print entitled "Subject systems—Clarification A Study for a Disposal Plant on Barren Island" (made in connection with Project J showing mark $\frac{100}{1B121}$ Jamaica Bay Div.) a blue print entitled "Disposal Methods—Screens Plan of proposed Screening Plant" (made in connection with project showing mark $\frac{100}{1B121}$ Jamaica Bay Div.) a blue print entitled "Disposal Methods—Sedimentation—Plan of proposed Layout of Emscher Tanks" (made in connection with Project J, showing mark $\frac{100}{1B12}$ Jamaica Bay Div.) a blue print entitled "Disposal Methods—Sedimentation—Section through proposed Emscher Tanks" (made in connection with Project J, showing mark $\frac{100}{1B121}$ Jamaica Bay Div.)

Report Dated January 24th, 1911.

I beg to hand you with this approximate plans and estimates as follows.

Project K—Jamaica Bay Division comprising screening and storage for sewage in 1960 from Brooklyn districts and discharge into Rockaway Inlet on the first four hours of the ebb tide; screening at Edgemere and discharge through tunnel to the ocean for sewage in 1950 from Queens and Nassau Districts.

Construction		$7,389,500
Annual Cost—		
Interest at 4½% and sinking fund 50 yrs. 5.06%	$373,900	
Maintenance	481,700	
		855,600

1579 (The report is accompanied by blue prints entitled Jamaica Bay Division, Project K, Preliminary Estimate.)

Report Dated February 1st, 1911.

I beg to hand you with this approximate plans and estimates as follows:

Project L—Jamaica Bay Division, comprising screening and storage for sewage in 1960 from Brooklyn districts and discharge into Rockaway Inlet on the first four hours of the ebb tide; treatment in Emscher tank and sprinkling filters on the marsh near Nigger point of sewage in 1950 from part of Queens and Nassau districts; screening at Edgemere and discharge through pipes to the ocean for sewage in 1950 from the Rockaway and part of Nassau districts.

Construction		$8,724,000
Annual Cost:		
Interest at 4½% and sinking fund—50 yrs. 5.06%	$441,400	
Maintenance	566,100	
		1,007,500

(The report is accompanied by a blue print entitled "Jamaica Bay Division, Project L, Preliminary Estimate.")

Report Dated February 21st, 1911.

I beg to hand you with this approximate plans and estimates as follows:

Project Z—Jamaica Bay Division—a revision of the project recommended by Col. W. M. Black and Prof. E. B. Phelps to the Board of Estimate, Nov. 18, 1910, comprising screening, aerating and discharge into Jamaica bay at two points into Rockaway inlet at one point and into the ocean at three points. The drainage districts and layout of interceptors taken are from their report and estimates of population and quantity of sewage are as used in Projects K and L.

1580 Coney Island and Nassau County districts are not included in the estimate. Grades are worked out to correspond with the flows as estimated by us.

The cost is estimated as follows:

Construction		$5,508,000
Annual Expense:		
Interest at 4½% and sinking fund,—50 yrs.—5.06%	$278,700	
Maintenance	398,200	
		$676,900

The cost per million gallons daily as compared with Projects K and L is as follows:

Project	K	L	Z
Construction per mgd	36,940	43,620	35,100
Annual Expense	4,278	5,038	4,310

For the population served, Project Z compares closely as to cost with Project K, but from the arbitrary limits assumed as to the lengths of interceptors, etc., any true comparison is difficult. The populations estimated by Col. Black are greater than those assumed by us and therefore the cost, as outlined by him, would be greater than in Project Z.

Fundamental differences between his plan and ours are

1. The omission of Nassau County.
2. The omission of Coney Island, whose sewage would be discharged either off Norton Point or at 92nd Street.
3. Interceptors are designed to run 0.8 full at times of maximum hourly discharge.

From the proximity of Coney Island to Rockaway inlet, the objection to pollution in the Upper Bay or off Coney Island and to storage during the flood tide at 92nd Street, as well as the necessity of pumping over the ridge to the latter point, the omission of Coney Island from consideration in connection with projects for Jamaica bay is not evident. Moreover, I am told by Mr. Fort that the 92nd Street outlet, as constructed, would not be adequate
1581 for this additional sewage.

As to the diameters of interceptors, if flowing 0.8 full, there would be an allowance for a variation in the maximum flow of not over 5%.

Now the daily variation above the mean flow at Deer island pumping station, Boston, was 63% in 1909. This would indicate that the 50% allowed for hourly fluctuations above the mean in our computations is not too great. Beyond this an allowance should be made for any possible fluctuation within the hour. In the Baltimore outfall sewer, the same allowance is made as we have used here, i. e. twice the mean flow. This, for long interceptors, may not be necessary, but a maximum capacity of but 50 to 55% above the mean flow, as assumed by Col. Black, does not seem sufficient.

Population densities do not vary greatly from those assumed by us, but densities of 50 per acre on Rockaway point (Dist. 51-A) and but 25 on District 6 (the eastern part of Jamaica) do not appear to be justified.

There are many cases of poor alignment and the grades are worked out for the inverts instead of the hydraulic grade, so that without drops in the former at changes of size, there would be liability of flooding in branch sewers. These matters, an evident error in the elevation of trunk sewer 38-39 and an unnecessarily deep cut (about 30 feet in Interceptor No. 1 (upper end and Sec. E) in Jamaica and in Interceptor No. 3 (lower end of I) at Concentration Point "E" are probably oversights and not material to the general scheme; but pumping stations at "M" and "N" as well as at Richie Point Marsh do not seem necessary, especially as the lift at "N" would be not over 2 or 3 feet, and as at "M" his invert is about 8 feet below the present ground surface. In Project Z, both these pumping plants are avoided, but with his steeper grades, due to smaller volumes, it might be best to pump at "M" to
1582 avoid too deep a cut at Richie Point Marsh.

The construction of a high level interceptor 12 miles long draining a district but from 0.5 to 2 miles wide and then pump it does not appear warranted when the sewage could all flow directly to low level interceptors without additional pumping. A possible reason for the high level interceptor is to discharge as much sewage as possible near the inlet, but much more might have been intercepted by lowering the grades.

The ocean outlets off Rockaway are about 700, 900 and 1200 feet from the shore and in about 15 feet of water. Considering the character of Rockaway beach as a bathing resort, these outfalls would probably prove objectionable during certain conditions of wind and tide. The same may be said, though perhaps in less degree, of an outlet some 2000 feet south of Norton's point, the construction and maintenance of which, in any case, might prove difficult.

Finally, as to Col. Black's estimate of the capacity of Jamaica bay to receive sewage, a large variation should be allowed due to the uncertainty of the tidal currents and those induced by the wind, where the network of shallow channels separating marches often submerged at high water render any attempt at precision useless.

Conclusions. To summarize briefly, I would say, regarding Col. Black's project:

1. It would be preferable to combine the sewage from Coney Island with that from the Paerdegat district rather than discharge off Norton's point or at 92nd Street.

2. Interceptors running 0.8 full, or having a capacity of about 55% above their mean daily flow, would probably be inadequate.

3. At least one pumping station—that at Concentration point "N"—seems uncalled for.

1583 4. The construction of a long high level interceptor from the eastern limits of Queens to the present 26th Ward plant seems unwarranted.

5. The construction of ocean outlets to moderate depths and to less than a half a mile out from important bathing beaches is inadvisable.

Aside from the above objections, the general lines of collection, the quantities of sewage estimated, the velocities assumed and the

points of outfall in Jamaica bay are well considered. Probably the long expensive temporary outfalls to reach remote channels, with increased pumping involved, would hardly be warranted, but otherwise are well selected. It is doubtful whether there would be an ultimate economy in establishing more than two disposal plants discharging to Jamaica bay, but as yet there are no figures to prove it.

The attempt to estimate the least permissible dilution is to be commended. Whether it would be of practical value with relation to outfalls in the interior of the bay is doubtful, but it might at least be applied with advantage at the inlet.

(Accompanying this report is a blue print entitled "Jamaica Bay Division Project Z, Preliminary Estimate.")

This report is dated April 29th, 1911.

The Report on the Sewerage of Jamaica Bay Division April 29, 1911

Contents.

1. General Conclusions 1421
2. Present Conditions 1422
Territory 1422
Population 1423
Drainage 1423
Jamaica Bay Improvement 1424
1584 3. Desirability of Main Drainage 1425
4. Conditions to be fulfilled 1426
5. Studies and estimates made 1426
Population 1426
Sewage 1427
Points of outlet 1428
Treatment 1429
6. Project M 1430
Interceptors 1431
Pumping stations 1431
Force mains 1432
Treatment 1432
Outlets 1432
Cost 1433
7. Project of Col. W. M. Black 1433
8. Plans of the Sewer Bureaus 1434
9. Desirable policy regarding the separate vs. combined system 1436
10. Storm water drainage and the Jamaica bay basins 1437
11. Early construction required 1440
Coney Island 1440
Shellbank 1440
Paerdegat 1440
26th Ward and Jamaica 1440
Far Rockaway 1442
Rockaway Peninsula 1442
12. Conclusions and recommendations 1442

1585 In accordance with your request I beg to hand you this report regarding the sewerage of the Jamaica Bay Division. The general conclusions arrived at are summarized as follows:

General Conclusions.

1. In the 105 sq. mi. area under consideration, a population of about 1,500,000 persons, or a total mean daily flow of 235,000,000 gallons of sewage, should be provided for.

2. The separate system should be adopted, where practicable. Where not practicable, the dry weather flow should be intercepted from the combined sewers, storm overflows provided and storm drains extended to the nearest suitable body of water.

3. To avoid a multiplication of treatment plants and excessive lengths of interceptors, sewage may best be concentrated by two main outlets, one of these; disposing of 166 mgd. into Rockaway inlet, the most favorable location for dilution, and one disposing of 65 mgd. into Broad channel, remote from the shore, but centrally located with respect to the area lying near the head of Jamaica bay.

4. The interceptors leading to these outlets should be located in general a mile or so from the bulkhead line on the north side and along the middle of the Rockaway peninsula on the south side. They would thus be on low-lying land, most of which can be drained directly without pumping, but below all important interferences except Fresh creek basin and Gravesend ship canal, where siphons would be required.

5. Main pumping stations are required on approaching each outlet, aside from which the only ones required on the main lines of interceptors are on Rockaway peninsula. Various subsidiary pumping stations would be required to pump from low-lying areas into the interceptors.

1586 6. Assuming perfect diffusion of 231 mgd. of effluent discharged into Jamaica bay, and no return of sewage on the incoming tide, the dilution would amount to 156 volumes at mean low tide. A rough estimate of the dilution required, if untreated, is 34 times the sewage volume (Rep. K. A. to G. A. S., Mar. 6, 1911), while the tidal prism is 156 times the sewage volume. (20.5)

A177

7. The treatment required should be the least consistent with non-offensive conditions. With this end in view, the treatment of the Rockaway inlet effluent at Barren Island might consist of plain sedimentation in Emscher tanks, while that discharged to Broad channel from a plant on Jo Cos Marsh should receive additional treatment equivalent to that by sprinkling filters.

8. The cost of the main drainage works as outlined, which would be adequate for 40 or 50 years, would be about $16,367,000.

Present Conditions.

Territory.—The territory under consideration is that naturally draining to Jamaica bay and Sheepshead bay, Coney Island and the

southerly, or ocean side, of Rockaway peninsula. In addition to this, 2.3 sq. mi. now draining to Gravesend bay, but in the near future to have its sewerage discharged through the 92nd Street outlet to the Narrows, have been included in the most recent study made (project M). Of the gross area of 105.1 sq. mi., 28.4 lie outside of the New York City line in Nassau County.

The total area, which is taken to the present shore line at mean tide level, will ultimately be somewhat increased in the future by filling in to the established bulkhead line in Jamaica bay. With the exception of that northern portion in the vicinity of
1587 the backbone of Long Island, the slopes are flat, averaging perhaps 4 or 5 feet in a thousand where above tide marsh level.

Population.—The present population approximates 370,000 persons, and the density varies from 0.1 per acre or less, near the head of the bay in Queens or Nassau, to 60 per acre just southwest of Evergreen cemetery in Brooklyn. The principal centers of population lie between the latter point and Jamaica, inclusive, at and near Bensonhurst, Coney Island, Flatbush, Canarsie, Far Rockaway and the middle part of Rockaway Peninsula.

Drainage.—The drainage of both Brooklyn and Queens is in general being carried out on the combined system, but there are important exceptions to this. In Brooklyn,—it is proposed to establish the separate system over a large part of Coney Island. Unionville, Sheepshead and a part of Flatbush are laid out on the separate system, while in East New York the dry weather flow is to be intercepted and extension made on the separate plan. In Queens, Jamaica and Far Rockaway are provided with separate sewers, and it is planned to use these on low lying areas requiring pumping, but, on the other hand, it is proposed to reconstruct the Jamaica sewers on the combined system. In general, the policy in both boroughs seems to be to employ the combined system, with storm overflow, if necessary, on the normal type, but to make exception of the large flat areas adjacent to the water front. (Drawing 2A—1131 III.)

The sewage at Coney Island, and with the exception of that discharged at Paerdegat creek and from the Rockaway peninsula, that discharged into Jamaica bay passes now through treatment plants, the principal ones being the East New York and the Jamaica plants. These are all inefficient and the outlets are not well located for the disposition of the effluent.

1588 At the present time considerable areas in or near Flatlands, Flatbush, Woodhaven and Richmond Hill, are about to be sewered, and the sewage of Bensonhurst and vicinity is to be collected to a pumping station at Avenue V and 11th Street, and diverted from Gravesend bay to the Narrows.

Jamaica Bay Improvement.—The proposed development of Jamaica bay as a harbor affects the situation regarding sewerage in several particulars.

1. The proposed long basins permit a discharge of storm water drains at the upper end instead of their extension to the shores of

the bay, and a consequent general lowering of the required ground surface in order to provide sufficient cover for them. The saving effected by one such basin a mile long, assuming the cost of a drain to be $100 per lin. ft. and filling over 2 sq. mi. a foot in depth at 20 cts. per cubic yard, would be $940,000.

2. With the street wash and a certain amount of sewage overflow entering during storms from the above drains, and the general pollution due to shipping, the condition of these basins especially near the upper end, where the effect of the tide is negligible, is quite likely at times to be unsatisfactory. The remedy for this consists in preventing all pollution possible, and then either flushing the basin or else treating its waters by some oxidizing or sterilizing agent.

3. The proposed improvement will cause an increase of population toward the water front.

4. The deepening of channels and filling in of land will alter the contents of the bay available for dilution to a certain extent, but as the government is not likely to permit a restriction of the tidal prism, which is of most importance for purposes of dilution, the present volumes are probably safe to use in computations.

5. The deepening of the channels will increase the cost
1589 of siphons necessary to pass under them.

3. Desirability of Main Drainage.

With a large prospective increase of population in Brooklyn near Flatbush and Flatlands, in Queens along the line of the Long Island R. R., and in both boroughs near the shores of Jamaica bay, and from the fact that the present disposal plants are not satisfactory, either in the method of treatment or capacity, extensive improvements in sewerage will be inevitable in the near future. To secure the greatest economy availing of the supply of oxygen replenished by the tide through Rockaway inlet to its fullest extent, and reserving the waters of the head of the bay for the disposal of restricted volumes of carefully treated sewage in order to avoid local putrefactive conditions, it appears evident that the question should be treated as a whole, without reference to political boundaries other than may prove inevitable.

4. Conditions to Be Fulfilled.

The conditions to be fulfilled include provision for:

1. The sewage of the entire territory so as t odrain cellars to a reasonable depth.

2. The maximum volume of sewage likely to occur at any time, added to unpreventable infiltration of ground water, with ample reserve for contingencies.

3. Velocities of flow that will prevent the formation of sediment on the one hand, or undue erosion of the invert on the other.

4. Such disposal of the effluent as will avoid nuisance from odors, the formation of deposits in the harbor, an unsightly appearance of the diluted effluent and, if practicable, detriment to fish life.

5. Studies and Estimates Made.

Studies have been made of various projects for the sewerage of this district. From the topographical conditions these all
1590 comprise the interception of the domestic sewage, or dry-weather flow of combined sewers along lines not far from the water front with pumpage to points of disposal.

Population.—In the more recent studies the population to be served in Brooklyn is estimated at 884,000 in 1960, with a maximum density in East New York of 90 per acre, while that in Queens is taken at 531,000 in 1950, with a maximum density in Richmond Hill and Woodhaven of 40 per acre. That part of Nassau county included is estimated to contain nearly 133,000 persons in 1950, with a maximum density near Inwood of perhaps 9 per acre; this total forecast population amounts to 1,548,500 provided for in the latest plans. It is assumed that a maximum transient population may occur at Coney Island of 400,000, furnishing 10 gallons of sewage per capita in 12 hours, and the same at Rockaway, equivalent in the resulting volume of sewage, to a resident population of 42,500 at each place, and these 85,000 persons are included in the total for the entire area mentioned above.

Sewage.—The sewage flow has been calculated in accordance with the principles agreed upon between you, Mr. Gregory and myself, and stated in Mr. Gregory's letter to you of October 6th, 1910.

The total forecast volume is estimated at 231 mgd., or an average of 150 gallons per capita daily, of which 25 gallons are due to infiltration. During wet weather this may increase to 50 gallons per capita.

The following tables gives a summary of the data regarding areas, population and sewage:

1591

Natural drainage to	Brooklyn.		Queens.	Nassau Co.	Total.
	Gravesend Bay.	Jamaica Bay.	Jamaica Bay.	Jamaica Bay.	
Drainage area sq. mi....	2.3	27.4	47.0	28.4	105.1 (B. and Q.) (363.693)
Population 1910 ..... **	13,000*	289,875	80,818	?	
Forecast population.....	59,900	824,200	531,600	132,800	1,548,000
Forecast sewage mgd ...	8.4	113.3	82.2	27.2	231.1

*Approximate.

**Brooklyn 1960. Queens and Nassau 1950, including 42,500 transient population at Coney Island and 42,500 at Rockaway.

Points of Outlet.—The points of outlet considered are:

	Projects.
1. Atlantic Ocean 8000 ft. off Rockaway Point...	G I N
2. " " 8000 and 4000 off Edgemere..	K L
3. Rockaway Inlet. All but.....	G I N
4. Grass Hassock Channel.....	E F
5. Broad Channel near Jo Cos Marsh.....	C D H J L M N

On account of the increasing use of Rockaway Beach for bath purposes, it has seemed best to eliminate further consideration of an ocean outlet. Rockaway Inlet at the mouth of Jamaica bay, with strong tidal currents, is a particularly favorable point of disposal, but to collect the sewage of the entire area at this place would mean conveying that from Nassau County, near the head of the bay, a very long distance. An outlet to serve this area is required, and Broad Channel, off Winhole Point, has been selected as probably offering the best conditions regarding dilution, besides being remote from the shore and proposed marginal channel. The outlets to the bay, proposed by Colonel Black (and worked up by us as Project Z) are at the inlet, to Broad Channel and to Big Fishkill channel, the latter two to be ultimately cut off near the pier-head line. The advantage of this third outlet is believed to be largely offset by the construction and maintenance of an additional treatment plant with a long submerged line of outfall sewer. The delivery of this sewage at the inlet would mean that it would enter the bay during the flood only, and then be diffused over its entire lower part.

1592 Treatment.—The kind of treatment depends largely upon the capacity of the waters of the bay to oxidize the effluent at the points of outfall.

Data.

Area of Jamaica Bay, including islands.....	26.90 sq. mi.
Area of Jamaica bay water surface.....	20.93 " "
Contents of Jamaica bay at mean low tide.....	2400 $\overline{m}$. cu. ft.
Mean tidal Prism Jamaica bay.....	2500 " " "
Mean sewage discharged in tidal period of 12½ hours	16 $\overline{m}$. cu. ft.
Mean tidal range, Rockaway inlet.....	4.5 feet
Mean tidal range, Norton point, Jamaica bay....	4.0 "
Mean proportion of land water in bay.....	10%
Mean dissolved oxygen in water of bay.....	6.6 parts per $\overline{m}$.

If the sewage discharged into the bay were thoroughly diffused throughout its waters, and if none returned with flood tide, there would finally be the constant quantity of 15,400,000 cubic feet in the bay $\frac{(20.5)}{(1B192)}$ at mean low tide.

The oxygen available to dispose of this sewage is estimated as follows: (20.5)/(A164)

Brought in by the flood current	685,000 lbs.
Absorbed from the atmosphere	280,000 "
Total	965,000 "

The oxygen required to dispose of the sewage is, in summer weather, by (20.5)/(A163) ..... 86,400 lbs.

The factor of safety is therefore 11

But at 53% of the effluent will pass directly out through the inlet during ebb currents, the factor of safety under the assumed conditions, would be, without any treatment, 23½.

From our present knowledge of the subject two outlets one at the inlet and one in Broad channel, would dispose of the estimated sewage to the best advantage.

Treatment.—As Jamaica bay is expected to furnish a harbor for considerable shipping, it may be assumed at the outset that no sterilization of the effluent would render its waters safe for the cultivation of shell fish. But as there is no inflow of upland water of any extent, any currents are mainly dependent upon the tides and winds, and near the head of the bay are necessarily slight and variable. For this reason it is believed the effluent to Broad channel should be in a stable condition, and should probably receive final treatment equivalent to that by sprinkling filters. At Rockaway inlet a less thorough treatment may be permitted, possibly sedimentation, or screening only.

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Project M.

Based upon the foregoing consideration and a process of elimination, Project M has been worked out as follows:

The entire territory is divided into two main districts.

One, of 49 sq. mi. contains a forecast population of 1,192,000, delivering 166 mgd. of sewage for treatment at Barren Island. This drains all the territory lying north of Jamaica bay, and west of Cornell creek.

The other comprises 56 sq. mi. and will contain a population of 356,000, delivering 65 mgd. of sewage to treatment work on Jo Coe March.

Interceptors.—The west side interceptor begins near the Jamaica disposal works, with a diameter of 5' 4" and, passing just south of the 26th Ward plants, under Fresh Creek basin by a siphon, past a pumping station, about to be built at the head of Paerdegat basin, and to the main or "Flatlands" pumping station near the west side

of the proposed Mill basin, where it will be composed of two 10′ 3″ x 10′ 3″ conduits.

The Gravesend interceptor starts from the pumping station to be built near Bensonhurst, with a diameter of 4′ 0″ and col-
1594 lecting the sewage pumped to it from Coney Island and Sheepshead on the way, joins the west side interceptor with a 7′ 3″ diameter, northwesterly from the Flatlands pumping station.

The east side interceptor begins about a mile southwest of Valley Stream with a diameter of 7′ 3″, increasing to 9′ 10″ by the time it reaches the Inwood pumping station, near the present Sloop Bar Hassock.

The Rockaway interceptor starts at Bell Harbor with a 25″ pipe, passing pumping stations at Hammels and Norton creek-, a 36″ force main is laid through Far Rockaway and with a diameter of 2′ 9″ it enters the Rockaway interceptor about a mile above Inwood pumping station.

Pumping Stations.—All the pumping stations are equipped with centrifugal pumps. At the Flatlands station the capacity is 350 mgd. lifted 35 ft.

At Bensonhurst the sewage to be pumped in the near future to the 92nd Street outlet will be diverted to the Gravesend interceptor. At Ocean Parkway sewage from both north and south will be pumped to the interceptor and at Avenue W and Nostrand avenue the sewage will be received from pumps at the present Shellbank plant. Pumps installed at Paerdegat, East New York and the Jamaica disposal plant will also deliver sewage to the interceptor.

The Inwood pumping station will have a capacity of 150 mgd. raised 31 ft. Besides the two pumping stations on the line of the Rockaway interceptor already mentioned, there will be required a pumping station near the mouth of Mott creek on a low level branch interceptor to extend later in a northwesterly direction.

The thorough drainage of the water front will require other small pumping stations in the future, probably operated
1595 automatically by electricity.

Force Mains to Disposal Plants.—From the Flatlands pumping station two 7′ 2″ force mains of reinforced concrete or wood stave construction will be laid for nearly two miles to the treatment works on Barren Island.

From the Inwood pumping station two 4′ 6″ mains of similar character will convey the sewage, first under the channel and then across the marsh land to the Jo Cos Marsh treatment plant.

Treatment.—Will comprise Emscher tanks and sprinkling filters.

Outlets.—The outlets for the clarified effluent will be in deep water in Rockaway inlet and Broad channel—two or more at each place.

Cost.—The cost of Project M, details of which are attached, is, exclusive of land and rights-of-way, as follows:

Estimate of Total Cost.

a. Including Sprinkling Filters at Barren Island.

	Total.	Per mgd.	Per capita.
Construction	$16,367,000	$71,000	$10.60
Annual charges	1,332,600	5,760	0.86

b. Omitting Sprinkling Filters at Barren Island.

	Total.	Per mgd.	Per capita.
Construction	$11,977,000	$51,800	$7.74
Annual charges	1,065,000	4,610	0.69

7. Project of Col. W. M. Black.

This project, which was discussed in my report of February 21, 1911 on Project Z, comprises discharge to Rockaway inlet, to Great Fishkill channel and Broad channel in Jamaica bay, to the upper bay off Nortons Point, or at the Narrows and to the ocean at three points of Rockaway Beach.

1596 As the maintenance of ocean outlets would be problematical in this exposed situation, and on account of their short distance (700, 900 and 1200 feet) from a beach used for bathing, these points do not seem to be well selected. The same objection applies to the Norton point outlet, which, although farther from shore, is near the northern end of the Ambrose channel, while that at the Narrows is open to the objection that during the flood current the sewage from an outside district is delivered into New York upper bay. Furthermore, the present sewers leading to the 92nd street outlet, do not have sufficient capacity to take this additional sewage for a long term of years, so that eventually a costly relief sewer would be required. Referring to pumping stations, there is no apparent reason for establishing that at concentration point "N."

"The construction of a high level interceptor 12 miles long, draining a district but from 0.5 to 2 miles wide, and then pumping the sewage, does not appear warranted when the latter might all flow directly to low level interceptors without additional pumping." (Rep. E. A. to G. A. S. Feb. 21, 1911.)

The construction and maintenance of 7 outlets and 3 treatment plants with long submerged temporary outfalls do not seem well advised, although the points in Jamaica bay appear otherwise well selected.

For the above reason no original project has been drawn up embodying the distinctive feature of this plant.

Plans of the Sewer Bureaus.

Drawing 2A-1131 111, submitted herewith, shows that, of the 105 square miles under consideration 27.8 square miles, or about one-

fourth of the whole, is provided with sewers; and of this
1597 part about half is on the combined and half on the separate system. On the remainder it is the intention of the Brooklyn bureau of sewers to install the separate system, and of the Queens bureau of sewers to adopt the separate system on those areas only, the sewage from which will have to be pumped. The latter includes 3.9 square miles to be drained to Barren Island, and 14.0 square miles to be drained to Jo Co Marsh. There are, therefore, some 29 square miles in Queens that it is the intention to develop on the combined plan. This includes Jamaica, whose present separate sewers are said to be inadequate, so that reconstruction will be required in the near future. Richmond Hills and Woodhaven are already being sewered under the combined plan (See report of Nov. 16, 1910).

The establishment of a pumping station near Bensonhurst in the near future has been mentioned.

It is also proposed to construct a pumping station at the head of Paerdegat basin to pump the sewage from 7.3 square miles of Flatlands and Flatbush to tide water. Relief from present conditions is urgent and this work will be undertaken soon.

At East New York the disposal plant is already entirely inadequate and the population increasing to such an extent that provision for caring for the sewage will have to be made very soon.

At Coney Island it is planned to pump the domestic sewage to the Bensonhurst pumping station, but the details have not yet been decided on.

In Queens and Nassau County there are large areas that will not require sewers for many years. The most pressing needs are in the vicinity of Jamaica, but extensions are also required and being planned for in Far Rockaway and along the Rockaway peninsula.

The question of disposal is not definitely settled in
1598 either Brooklyn or Queens, but it may be said in general that the present treatment is not satisfactory, that ocean outfalls are not viewed with favor, and that in Queens it is hoped that the expense of sprinkling filters will not be necessary.

Desirable Policy Regarding the Separate vs. Combined System.

The area provided with combined sewers are in general those having the densest populations and which at the same time lie at such an elevation that pumping will not be necessary.

To avoid the considerable expense of reconstruction, it is suggested that the sewers of these districts remain in general as they are for the present. The dry weather flow should be intercepted for treatment with that from separate systems, as the cost of treating the storm water at the disposal plants would be prohibitive. But it should be remembered that the overflow to storm outlets will carry, besides grit and other polluting matter, from street surfaces, a proportion of domestic sewage, and this may cause objectionable conditions near the bulkhead line, or, in particular, in the long proposed basins for shipping. For this reason every effort should be made to cur-

tail the extension of combined sewers, even in the districts most suitable for their use, and to this end if the existing sewers become, at any time, inadequate, instead of constructing reliefs on the combined system, the old sewers may be utilized either for domestic sewage and new ones built for storm drainage or vice versa, as most economical in the specific case under consideration.

1599 And in the remaining territory the separate system should be established, as most desirable where sewage is to be treated and because it is believed to be otherwise most economical. The depths of the separate domestic sewers would be about the same as in the combined system, but the size would be much smaller, the minimum diameter being, probably, 8 in. instead of 12 in. and the larger diameter differing t yet greater degree. The cost is therefore much less than for combined sewers, to say nothing of the excessive cost of pumping and treating combined sewage. This saving is in part offset by the construction of storm drains, which in some cases are as costly as the combined sewer would be. But in general the requisite depth is much less, and, too, large suburban areas demanding sewerage facilities will not feel the need for storm drainage for many years, so that the fixed changes on large outlays for sewerage may be indefinitely postponed. Moreover, if left until the necessity arises, storm drains can be designed to more fully meet the conditions then existing, than if built before knowledge can be had of the future developments of the territory. If designed for an ultimate run off of 90% when, through some unforeseen shift of population, 70% would have been adequate, the loss in first cost might be a large sum of money.

In short, the separate system, as a general proposition, would probably be, on the whole, the most economical as well as the one emphatically best adapted to the ends to be reached. In the case of Jamaica bay, however, there is the serious condition to be met in the construction of proposed basins.

Storm Water Drainage and the Jamaica Bay Basins.

No solution of the disposal of the domestic sewage of this territory will be adequate that does not also provide
1600 for the disposal of the storm water, and in this connection the construction of the Jamaica bay basins is a very important consideration. As to the limited area draining to Gravesend bay and the ocean, it may be assumed that storm water discharged at well selected points will not be objectionable. In the case of Jamaica bay questions of deposits and putrefactive conditions have both to be met. There are but four ways of doing this, viz.,

1. By preventing polluting matter from entering the basin.
2. By purifying the polluted water after entering the basin.
3. By sterilizing the water of the basin to defer putrefaction.
4. By removing the polluted water before putrefaction sets up.

1. Sedimentary matter should in any case be intercepted, so far as practicable, in grit chambers and unavoidable deposits dredged out. Most of the objectionable organic matter cannot be intercepted

in this way, and can only be prevented from entering the basin by diversion. To accomplish this it would either be necessary to pump to outlets near the pierhead line, or to extend the drains with suitable grades to these points. Either of these plans would entail an enormous expenditure.

2. The organic matter in solution and suspension could possibly be treated before or after admission to the basin by peroxide of manganese ozone, or some such oxidizing agent, or perhaps by direct aeration, in such a way as to secure sufficient purification and to avoid objectionable conditions.

3. The lack of any appreciable displacement of the water at the head of each basin, except during heavy storms, precludes any
1601 consideration of sterilization as a practicable preventive of putrefaction, as this would be sure to occur sooner or later.

4. By a prompt and regular removal of the water near the head of the basin objectionable putrefactive conditions would be avoided: For the lower part of the basin the tidal prism will accomplish this, as explained in my report of November 22, 1910. Moreover, it is believed that the depth of these basins instead of being 18′ at M. L. W. as formerly assumed, is more likely to be 10 ft. which will extend the influence of the tidal prism from the bulkhead line. But the head of the basin is likely to remain stagnant.

A current induced by connecting the heads of the basins by a canal would afford relief, but is impracticable on account of its cost, and its interference with traffic and drainage.

The only other recourse would be in pumping to or from the basin, as in the case of Gowanus canal. It is possible that, by careful exclusion of unnecessary pollution this might be done on a moderate scale, and effect the desired result, but it seems probable that the cost of installing pumps at each basin capable of creating a sufficient renewal of the twenty or thirty million cubic feet of L W contents, would be almost prohibitory.

The plans that seem to warrant further consideration are, therefore, either oxidation by chemical or aeration, or else renewal of the water by pumping.

Possibly the experiments of Prof. Phelps on oxidation and the results following the flushing of the Gowanus canal, may throw valuable light on this question.

1602 Early Construction Required.

Improved sewage facilities are demanded for:
1. Coney Island.
2. The vicinity of Shellbank treatment plant.
3. " " " Paerdegat basin.
4. " " " 26th Ward Treatment plant.
5. " " " Jamaica " "
6. The southern part of Far Rockaway.
7. " Rockaway peninsula.

Coney Island is to be provided for by the Bensonhurst pumping

station, which plan may readily be adapted to final construction along the lines of Project M.

At caisson No. 2 screens of bars ½" apart and a centrifugal dryer for the sludge are to be installed.

Shellbank treatment plant may have to be either temporarily enlarged or improved to provide for the immediate future.

Paerdegat A pumping plant is to be installed here to care for the new low-lying sewers. It is probable that a temporary treatment plant will also be required to avoid objectionable conditions.

26th Ward and Jamaica Plants.—These plants and the effluent flume from the former require remodelling at once. The volume to be treated is increasing rapidly, so that it cannot all received even the present inefficient clarification intended.

It is suggested by the Brooklyn bureau of sewers that the sewage of Jamaica be conveyed to the 26th Ward plant by an interceptor to be built on the final lines of Project M, and the sewage of the combined drainage areas there treated by a plant to be built: This plant could be of temporary construction and abandoned on the later extension of the interceptor to Barren Island. If, however,
1603 the cost of an adequate temporary plant should be too great, it might be more economical to install a permanent plant at this point, collecting to Barren Island only the sewage of the part lying west of Canarsie.

This interceptor would ultimately carry 68.4 Mgd.

from a population of 308,300 in Queens and 76.3 Mdg.
" " " " 377,700 " Brooklyn or 144.7 "
" " " " 686,000 in all.

But supposing that by ten years this sewage could be taken to Barren Island for treatment, it is hardly likely that the low lying areas in Southern Queens and near Jamaica south, would be developed. Omitting these districts (XIV, XXI and XXII), it is estimated that, while the present flow is, perhaps, to:

Jamaica	plant	2.5 mgd.
26th Ward	"	22.5 "
Total	.....	25. "

by 1921 this will have increased to:

16.1 mgd. from Queens
33.5 " " Brooklyn

49.6 " or, say 50 mgd. in all for which treatment would be necessary.

Under these circumstances, it is recommended that the method of treatment and its cost under this plan be looked into further with a view of its advisability.

Far Rockaway.—It is understood that preliminary plans for ex-

tensions of the Far Rockaway sewerage have been worked up, comprising two more Shone ejector stations. As collection would be to the present disposal plant, no modification of Project M would be required.

Rockaway Peninsula.—The sewage here may be carried by a collector to Far Rockaway (as proposed) or to Rockaway point (as in projects G. I. N.) or it may be discharged at several points
1604 (as in Project Z). Owing to the objection to ocean outlets, or the multiplication of treatment plants on the bay side, the latter plan is not approved. Therefore, two or more small pumping stations become necessary to avoid excessive costs in the saturated soil. The plan of collecting at Far Rockaway, as by Project M, meets the approval of the Queens bureau of sewers.

12. Conclusions and Recommendations.

1. The territory draining to Jamaica bay should be considered as a whole in any scheme for main drainage.

2. The separate system should be adopted wherever practicable.

3. Collection should be to treatment plants discharging to the inlet and Broad Channel, with a provisional outlet off Second Creek.

4. With perfect diffusion 34 times the estimated volume of sewage (about the year 1955) could be discharged into the bay without treatment, without resulting putrefactive conditions.

5. In this territory, as outlined in Project M, a population of 1½ million persons and a mean flow of sewage of 235 Mgd. should be provided for.

6. The cost of this project if carried out would be about $16,367,000, and the annual charges about $1,332,600.

7. In all essential particulars, excepting the adoption of the separate system in Queens, the details of project M harmonize well with the ideas of the Engineers of the sewer bureaus and with their projected work.

8. Further studies should be made to ascertain the degree and method of treatment required for the disposal of sewage in Jamaica bay, particularly at the inlet, in Broad channel, and in Big channel off Second creek.

9. Studies for the collection and temporary treatment of
1605 the sewage of Jamaica and East New York in the near future at the 26th Ward disposal plant should be made.

10. If the cost of such a disposal plant should be so great as to make its construction as a permanent plant probably the most economical plan, studies should be made of a project comprising this as a permanent feature, the balance of the Brooklyn area draining to Barren Island, as in Project M.

11. Studies should be made of the feasibility of protecting the proposed Jamaica Bay basins from pollution, either by oxidation of the water or their renewal by pumping.

Acknowledgments are due to Mr. D. W. Belcher, who has been of material assistance in the preparation of the plans and estimates for the various projects worked out.

Drawings accompanying this report are:
1. 2A—1131—111 Areas provided with sewerage.
2. C—1127—11—111 Map of Project M.
3. S—1128—11—111 Profiles of interceptors, Project M.
4. Proposed location of treatment plant, Barren Island.
5. 1B 20.21—236 Proposed design of Emscher tank.
6. 1B 20.21—237 Proposed arrangement of Emscher tanks, Barren Island.
7. 1B 20.21—242 Preliminary estimate of Project M.
8. 1L—1132—111 Part of Project M proposed for early construction.

Redirect examination by Mr. O'Sullivan:

Q. Did you undertake any line of investigations to determine the advisability of reconstructing the sewerage system of New York or Manhattan?
A. I did, for Manhattan.
Q. Did you later shape such knowledge as came to you in your line of work on that particular topic as a report and submit it to the Metropolitan Sewerage Commission?
A. I did, July 14th, 1910.

Recross-examination by Mr. Riker:

1606 Q. Mr. Allen, this is your own idea of a proper system of sewerage or sewage disposal for the Island of Manhattan, the Borough of Manhattan?
A. Well, I would not claim that it was original with me. It is based on the conditions as far as I was able to determine the present conditions and the probable conditions as affected by the building of subways and so on, and what seemed to me to be the best action to take with reference to the construction of the sewers.
Q. The final term "conclusion" is your idea of the proper disposal of the sewage of the Island of Manhattan?
A. Not so much the disposal as the collection.
Q. The collection?
A. Yes, the lines of sewage, reconstruction of the sewers themselves.
Q. So as to bring the sewage to certain points?
A. Yes.
Q. That is all you were concerned with?
A. Yes.
Q. Has it been adopted?
A. It has, one part, not my particular report, but the idea has been partly used.
Q. By whom?
A. By the Borough of Manhattan.
Q. What part?
A. The Consulting Engineer of the President of the Borough told me that south of Chambers Street they had decided to reconstruct

the sewers on the separate system, and that is in accordance with the ideas of this report.

Q. Do you know how it was that they had decided that; did he tell you how they had decided that?

A. The Borough President I suppose, decided.

Q. You do not know, as a matter of law whether that constitutes a legal adoption of it?

A. No.

Q. So that so far as you know, no part of your project has ever been legally adopted and put into execution?

A. Yes, there is one area near 120th Street, East 120th Street, that is they have adopted that plan for that area as a first trial.

1607 Q. Had they adopted it prior to your report?

A. No.

Q. They have adopted it since?

A. Yes.

Q. And with that exception this is pure speculation on your part, is it not?

A. I do not know of any speculating in it. It is an opinion.

Q. It is an opinion on what ought to be done, but not as to what is going to be done?

A. Yes.

Mr. Riker: I object to the reading of the report on the grounds stated for the last report, and on the ground that this is purely a hypothetical and speculative dissertation.

The Commissioner: Note the objection of counsel for Defendants.

Redirect examination by Mr. O'Sullivan:

Q. State the contents of that report?

A. This report is dated July 14th, 1910.

I beg to report as follows concerning the advisability of reconstructing the sewerage system of Manhattan.

Relation of Subways to Sewers.

If the sewers of Manhattan are to be reconstructed, the sooner a decision on this point is reached the better. Prominent among the reasons for reconstruction is the prospect of the interference and consequent relocation of many existing sewers resulting from the construction of subways. Admitting that the inverts of the sewer lie ordinarily at a depth of 13 feet below the pavement and that the subways will require some 20 feet of space from top to bottom outside, and, to provide easy entrance and exit and good ventilation that they will be located as near the street surface as practicable, it is at once seen that an immense amount of costly sewer reconstruction will be necessary in laying down the lines of subway already approved by the city authorities. These include, besides the

1608 lines in operation, the following:

1. The Manhattan Bridge Route, lying in Canal Street.
2. The Brooklyn and Manhattan Loop Line, lying chiefly in Center and Delancey Streets.

3. The Thirty-fourth Street Crosstown Route.
4. The Third Avenue Route.
5. The Seventh and Eighth Avenue Route.
6. The Lexington Avenue Route.
7. The Fourteenth Street, University Place Route.
8. The Brooklyn, Manhattan and Long Island Route, lying in part in Canal Street, East of Ave. B.
9. The Canal Street Route, lying in Canal Street, northwest of Center Street.
10. The First Avenue Route.
11. The West Street and Ninth Avenue Route.

In addition to these, plans have been prepared, but their adoption deferred for crosstown lines in Twenty-third and Fifty-ninth Streets.

Of the above eleven adopted routes, the first two are in process of construction; numbers three to nine, inclusive, have been validated by consent of the property owners or by authorization of the Appellate Division, while numbers ten and eleven remain as yet unvalidated.

Aside from those under construction, the Lexington Avenue Route is the only one the details of which have been finally fixed and there is the possibility that even this route may be abandoned, in case bids for construction are not forthcoming, in favor of a plan recently proposed by President Shonts of the Interborough Rapid Transit Co.

1609 For purposes of forming an opinion of the interferences likely to be met with in the construction of these future subways, the Lexington Ave. plans would appear to furnish the only reliable information available at this time. The plans for sewer reconstruction along this route have been prepared, and, through the courtesy of Mr. E. P. Goodrich, Consulting Engineer to the Borough President, I have examined these.

By intercepting sewers on Nineteenth, Twenty-second, Twenty-third, Thirty-second, Forty-first, and Forty-second Streets and carrying them under the subway at Thirtieth Street in the equivalent of an 8 ft. circular sewer, the number of siphons required has been reduced to two, viz. at One Hundred and Sixth Street, comprised of two 24 in. dry weather pipes and two 48 in. storm water pipes, and at One Hundred and Tenth Street, comprised of two 42 in. dry weather pipes and 2-6 ft. 9 in. storm water pipes. The base of rail at these streets is at an elevation of 91.0 and the sewer inverts are at elevations ranging from 98.4 to 100.67. Provision has been made in the design for the inspection, pumping out and cleaning of these siphons. To avoid their construction by lowering the grade of the subway Mr. Goodrich says has been estimated to cost $1,000,000 more than by the present plan.

The cost of lowering a line of subway is very great for the following reasons:

1. The cost of excavation is increased proportionally with the depth, being in open cut (unless very deep) and an increased amount due to the greater average depth.

2. The cost of sheeting, maintaining and pumping the trench increases rapidly with the depth.

3. A deep trench results in a larger per cent. of rock excavation, increasing the cost.

1610 4. Any increase in depth means increased difficulty in preventing seepage through the water-proofing in spite of all precautions. This is an important consideration.

5. The cost of maintenance and operation are materially increased by the greater difficulty of proper ventilation and by the necessity of operating passenger elevators at the stations.

For these reasons strong objections could be made and probably sustained to such a material lowering of subway grades as to preclude the necessity of any siphons.

The probable necessity for siphons on each north and south subway, therefore, is one reason for reconstruction of sewerage systems on new lines.

Taking the Lexington Avenue Route as a sample, the extra cost due to siphons is a comparatively small matter, but an examination of the plans shows a very large amount of new construction due to the readjustment of lines and grades found necessary. The money required for this might better be applied to the comprehensive revision of the entire system.

It is evident that subway construction is going to cause numerous costly relocations resulting, in general, in lengthening the sewers and therefore providing light grades with a poorer alignment than as originally constructed. In many cases the revised grades may be sample, but in others it will mean greater liability to the collection of sediment. Detours are made around passenger stations preventing proper inspection and inviting the collection of obstructions. Siphons will be required in various places. These are to be avoided where possible, but in the case of siphons of over 7 or 8 feet in depth and with combined sewers, they may be said to be positively objectionable on account of the possibility of clogging, the diffi-

1611 culty and uncertainty of cleaning and of the damage to property likely to result.

A careful revision of the entire system, taking the above facts into consideration, would furnish a more satisfactory and harmonious result than could possibly be reached by the separate consideration of each local case of interference as it arose, and would probably be less costly in the end.

Other Reasons for Reconstruction.

Aside from a better adjustment with the lines of subway, there are imperative reasons for reconstructing certain parts of the present sewerage system. Our inspections of the sewers showed a serious condition at many points, more especially in the older ones. An examination of the reports of 246 inspections indicates that at 38 locations or one-sixth of the entire number inspected, it is probable that the sewers will have to be rebuilt within a few years on account of defective brickwork alone. These are as follows:

1. Rivington St. near Suffolk St.
2. Fulton St. " William St.
3. Worth St. near Broadway.
4. Worth St. " "
5. West St. " Pier #7.
6. Franklin St. " Church St.
7. 2nd St. " Ave. A.
8. 7th St. " 3rd Ave.
9. 8th St. " Ave. C.
10. 8th St. " " D.
11. " " " Lewis St.
12. " " " Ave. C.
13. Ave. C. " 9th St.
14. 13th St. " 6th Ave.
15. 14th St. " 1st Ave.
16. " " " Ave. D.
17. " " " " "
18. 15th St. " 5th Ave.
19. 15th St. West of Union Sq.
20. " " near Ave. B.
21. 18th St. " Ave. A.
22. " " " 1st Ave.
23. 20th St. " Irving Place.
24. 23rd St. " 7th Ave.
25. 26th St. " Broadway.
26. " " " 7th Ave.
27. 34th St. " 1st Ave.
27. 34th St. " 1st Ave.

1612

28. 42nd St. near 11th Ave.
29. 63rd St. " Ave. A.
30. 79th St. " Park Ave.
31. " " " 3rd Ave.
32. 80th St. " Hudson River.
33. West End Ave. near 85th St.
34. 8th Ave. between 89th and 90th Sts.
35. 106th St. near Park Ave.
36. 5th Ave. near 131st St.
37. 145th St " St. Nicholas Ave.
38. 147th St. " 8th Ave.

Of the 522 miles of existing sewers, which have been estimated to cost $26,000,000,* 55 miles or 10½% are said to be out of repair. To repair these at half the cost of construction, which is probably conservative, would mean an outlay of $1,375,000 in itself, which might be applied to more radical reconstruction.

Sewers more carefully designed and built than many of the old sewers would require less cleaning, resulting in a further offset to their cost.

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*Report M. S. C., 1910, p. 229 p. 235.

The Separate System.

Finally, a reconstruction of the sewers would permit the adoption of the separate systems, provided this were of advantage. The question of separation is one of much importance and one that it would be well to consider in this connection.

By the separation of storm water and sewage, several important advantages would result.

1. By locating the sewers generally parallel to the subways, and crossing under these where necessary, at a depth at least sufficient to drain all ordinary basements, the use of siphons could be practically eliminated and the cost to property holders of pump-
1613 ing from their basements to the sewer generally avoided.

2. The removal of such deposits as might occur could be more readily effected by flushing.

3. The comparatively small size of the sewers would permit a choice of location in congested streets with improved alignment and grade.

4. If ultimately pumped, the cost of handling domestic sewage only would be greatly reduced.

5. If the sewage is to be purified or treated in any way, separation would be desirable and the elimination of excessive storm water a necessity for reasons of economy.

6. By locating storm water drains near the surface, they will generally pass over subways without interference.

7. They may be given better grades and so kept freer of deposit.

8. Their cost would be less, both for construction and cleaning.

9. By this plan it would be practicable to omit the use of the 14,000 catch basins with their costly maintenance permitting street dirt, after suitable screening, to be washed directly to the drain. The cost of street cleaning would be greatly reduced in this way; and while some of the dirt would deposit in the drains and in the rivers after being discharged, much could be intercepted by grit chambers and the removal of the balance would probably be less costly and more efficiently accomplished than through the medium of the catch basin.

In connection with this work, the cost of revising the house drainage system in some 178,000 premises should be taken into account, as well as the cost of the sewers and drains themselves. On
1614 the other hand, by a careful study of the existing sewers, it seems probable that many of the newer ones, either in part or in whole, can be utilized as storm water drains with a large saving to the Borough.

Conclusions.

The resultant cost will in any case be very great, but taking into account the unavoidable costs without general reconstruction and the imperfect result that would then be reached, the conclusion is reached that such a general reconstruction of the sewerage of Manhattan on the separate system should be made, having in view the requirements of the subways to be built hereafter and the final disposition to be made of the sewage effluents.

Suggestions.

Principles Governing Design.

Sewers—Should be at depth at least sufficient to drain basements of ordinary depth and should receive all domestic sewage. They should collect to mains, running parallel to subway, crossing under these to deliver to points of disposal or pumping stations.

Storm Water Drains—Should be laid on direct lines to the water front starting as near the surface as practicable to insure adequate gradients for flushing. Catch basins should be omitted, but the street wash should be screened and grit chambers introduced in the drains near invert, elevation O, that is, as near the outlet as practicable to clean them. If practicable, the invert should be given this elevation at the mouth.

Existing sewers of proper design and construction can be utilized for storm water drains except such portions as lie above points where they are cut by subways. Catch basins might be retained on portions near outlets submerged at mean tide.

1615 No siphons should be permitted on storm water drains. If otherwise impossibe to avoid them, the projected subways interfering should be lowered.

Appendix.

Mr. Hering has recommended the reconstruction of the sewers of Manhattan on the separate system in his report to J. F. Ahearn, Borough President, of April 21, 1908. Mr. Horace Loomis, Chief Engineer of the Bureau of Sewers and Mr. E. P. Goodrich, Consulting Engineer for the Borough have endorsed the idea. Mr. A. S. Tuttle of the Board of Estimate and Appointment is not prepared to express an opinion on the matter at this time. He believes separation may be advisable for certain areas, but he hopes that experiments now being carried on by the Board may throw further light on the problem, possibly avoiding the necessity of separating the storm water.

Mr. Amos Schaeffer, Consulting Engineer, Borough of the Bronx, believes that the separate system will ultimately be adopted, but that on account of the great cost, it may be best to introduce the change as the necessity is felt. For instance, a part of the money required for reconstruction on account of subway construction might well be applied in rebuilding the sewers of that district—at least those lying above the subway—on the separate system. Any additional cost due to separation would have to be met by the city, and this, including the cost of remodeling the house drainage, Mr. Schaeffer is inclined to think would be met by direct assessment on the property, according to the current policy of the Board of Estimate to avoid an increase in bond issues except for exceptional purposes.

1616 Mr. Schaeffer mentioned as an example where, in his opinion, the separate system might well be introduced in

connection with the proposed Lexington Ave. Subway, the comparatively limited area lying between Broadway and Greenwich Street and South of Vesey Street.

Referring to the use of siphons, Mr. Schaeffer mentioned that crossing the Lenox Ave. branch of the subway at 149th Street, as working without difficulty up to the present time, but he says the retention of stagnant water in it between storm results in septic conditions producing very foul odors. It has been suggested to allow a constant stream of water to pass through in order to avoid this condition.

(This report is accompanied by a blue print entitled Manhattan Subway Routes.)

At 1:15 adjourned to meet again in the Finance Committee Room of the Board of Aldermen on January 31st, 1912, at 10:30 A. M.

1617 Supreme Court of the United States, October Term, 1911.

THE PEOPLE OF THE STATE OF NEW YORK, Complainants,
against
STATE OF NEW JERSEY and PASSAIC VALLEY SEWERAGE COMMISSIONERS, Defendants.

CITY HALL, NEW YORK CITY,
January 31st, 1912—10:30 a. m.

Present: James D. Maher, Esq., Commissioner.

Appearances:

Dr. William J. O'Sullivan, Special Counsel for the People of the State of New York.

Joseph Coult, Esq., of Counsel for the Passaic Valley Sewerage Commission.

Met pursuant to adjournment.

Owing to the indisposition of the Commissioner, the hearing was adjourned until February 1st, 1912, at 10:30 A. M.

Adjourned to February 1st, 1912, at 10:30 A. M.

1618 Supreme Court of the United States, October Term, 1911.

THE PEOPLE OF THE STATE OF NEW YORK, Complainants,
against
STATE OF NEW JERSEY and PASSAIC VALLEY SEWERAGE COMMISSIONERS, Defendants.

CITY HALL, NEW YORK CITY,
February 1st, 1912—10:30 a. m.

Present: James D. Maher, Esq., Commissioner.

Appearances:

Dr. William J. O'Sullivan, Special Counsel for the People of the State of New York.
Adrian Riker, Esq., of Counsel for the Passaic Valley Sewerage Commission.
Joseph Coult, Esq., of Counsel for the Passaic Valley Sewerage Commission.

Met pursuant to adjournment.
Owing to the continued indisposition of the Commissioner the hearing was adjourned until February 5th, 1912 at 10:30 A. M.

Adjourned to February 5th, 1912 at 10:30 A. M.

1619 Supreme Court of the United States, October Term, 1911.

THE PEOPLE OF THE STATE OF NEW YORK, Complainants,
against
STATE OF NEW JERSEY and PASSAIC VALLEY SEWERAGE COMMISSIONERS, Defendants.

CITY HALL, NEW YORK CITY,
February 5th, 1912—10:30 a. m.

Before James D. Maher, Esq., Commissioner.

Appearances:

Dr. William J. O'Sullivan, Special Counsel for the People of the State of New York.
Adrian Riker, Esq., of Counsel for the Passaic Valley Sewerage Commission.
Joseph Coult, Esq., of Counsel for the Passaic Valley Sewerage Commission.
Robert H. McCarter, Esq., Special Counsel for the State of New Jersey.

Met pursuant to adjournment.
The following telegram is self explanatory.

"WASHINGTON, D. C., Feb. 4-5, 1912.

New York:

Dr. W. J. O'Sullivan, Asst. Corporation Counsel, Hall of Records,

Owing to severe cold will have to postpone hearing in New York against New Jersey until further notice. Have wired New Jersey Counsel.

JAMES D. MAHER,
Commissioner.

12.21 a. m.

1620 Mr. Riker: By direction of the Commissioner by reason of his inability to be present on account of sickness the matter stands adjourned until further notice.

Adjourned until further notice.

1621 Supreme Court of the United States, October Term, 1911.

THE PEOPLE OF THE STATE OF NEW YORK, Complainants,
against
STATE OF NEW JERSEY and PASSAIC VALLEY SEWERAGE COMMISSIONERS, Defendants.

CORPORATION COUNSEL'S OFFICE, NEW YORK CITY,
February 27th, 1912—10:30 a. m.

Before James D. Maher, Esq., Commissioner.

Appearances:

Dr. William J. O'Sullivan, Special Counsel for the People of the State of New York.
Robert H. McCarter, Esq., Special Counsel for the State of New Jersey.

Pursuant to notice sent to counsel for the respective parties, the taking of testimony was resumed.

HARRY DE BERKELEY PARSONS, a witness called on behalf of complainants, being first duly sworn, testified as follows:

Direct examination by Mr. O'Sullivan:

Q. Your full name?
A. Harry de Berkeley Parsons.
Q. And you are a resident of this City?
A. I am.
Q. With an office where?
A. 22 William Street.
Q. Where were you educated Mr. Parsons?

A. I was educated in private schools and with tutors first in New York and then in Europe.

1622 Q. What states in Europe, or what countries?

A. France, England, Italy, Germany, Russia.

Q. Now, did you graduate at any of our American institutions?

A. I did. On returning from Europe I entered Columbia and was graduated in 1882.

Q. As what?

A. I received the degree of Bachelor of Science.

Q. Did you take any subsequent degrees?

A. Yes, after graduation from Columbia, I entered Stevens Institute of Technology and was graduated from there in 1884.

Q. Taking what degree?

A. Receiving the engineering degree.

Q. Where is the Stevens Institute of Technology?

A. In Hoboken, New Jersey.

Q. Do you belong to any of the societies of engineers?

A. I do. I am a member of the American Society of Civil Engineers; the American Society of Mechanical Engineers; the Society of Naval Architects and Marine Engineers.

Q. Are you a member of any of our civic bodies, Mr. Parsons?

A. I am a member of the Chamber of Commerce of the State of New York. I am a member of the Merchants' Association of New York.

Q. Do you belong to any of the national societies that are interested in the subject of sewer pollution?

A. I am a member and also a member of the executive committee, of the National Association for Preventing the Pollution of Rivers and Waterways.

Q. Have you had any experience in mine working and in railway operations?

A. I have, more in railway operations than in mines. I did some work in the Pennsylvania coal fields and I did some work on the Erie Railway. I built the first section of the Fort Worth & Rio Grande Railway in Texas, running from Fort Worth southwesterly.

1623 I have done considerable work in examination, appraisement and reports of railways as for instance, the Seaboard Air Line railway, and for other systems like that.

Q. Now, for how long have you had an office in this city?

A. I have had an office since 1885. That is 27 years, a little over. My first office was at 35 Broadway and then I moved to my present address, No. 22 William Street, where I have been for twenty years.

Q. Have you filled a teacher's chair in any of our technical schools?

A. I have. In 1891 I was appointed lecturing professor in Engineering at the Renssalaer Polytechnic Institute, Troy, New York, which chair I held until 1907 at which time I resigned on account of not being able to give sufficient time as the classes increased so largely in numbers and my resignation was accepted, and I was appointed immediately Professor Emeritus of Practical Engineering, which position I now hold in the same institution.

Q. Are you a member of the Metropolitan Sewerage Commission?
A. I am.
Q. When were you appointed?
A. I was appointed by Mayor McClellan in 1908.
Q. Have you contributed to the literature of your profession?
A. I have. I wrote a book on Municipal Refuse and its disposal and I wrote a book on Steam Boilers, their theory and design, and I contributed a number of papers to the Engineering Journals and Technical Press on engineering subjects, many of which have been along the lines of sanitation.
Q. Have you occupied the position of consultant to any departments in your profession?
A. I have been at various times consulting engineer to the Department of Street Cleaning in this City; to the Fire Department; to the Police Department; Department of Charities and Cor-
1624 rection—that is the old Department of Charities and Correction; the Dock Department; the Board of Estimate and Apportionment, and through that Board, the Board of Water Supply.
Q. Have you made any special study of our harbor conditions?
A. I have.
Q. Will you describe briefly the harbor of New York?
A. The harbor of New York consists in brief of the lower bay the upper bay the East River, the lower Reaches of the Hudson River, the Kill von Kull, the Arthur Kill, Newark Bay, and Jamaica Bay. The Lower Bay is situated at a re-entrant angle of the Coast Line, and is a broad expanse of water open to the Atlantic Ocean. The Upper Bay is joined to the Lower Bay by a narrow channel or strait, known as the Narrows. The Narrows, the Arthur Kill and the Kill von Kull are the waters which surround the Borough of Richmond, commonly known as Staten Island. The Upper Bay is a body of water north of the Narrows, into which flows the Kill von Kull the Hudson River and the East River. Newark Bay is joined by the Arthur Kill to the Lower Bay and by the Kill von Kull to the Upper Bay, and into it flows the Hackensack and the Passaic Rivers. The Hudson River is by far the largest of the streams entering the harbor. The East River, socalled, is really a strait joining Long Island Sound, which is an arm of the sea, with the Upper Bay. The East River and the Hudson River are joined by the Harlem River, which is also a strait and this Harlem River, Hudson and East Rivers make the Borough of Manhattan an island. The characteristics of the different parts of the Harbor vary considerably one from another. Some are quite shallow, some have considerable depths of water but in the main the water principally lies in the channels on either side of which the harbor is more or less shallow.

Q. Have you made a study of the tidal actions in New
1625 York Harbor?

A. I have.

Q. What are the areas of water surfaces of the several divisions of the harbor?

A. The water surfaces of the several divisions of the harbor as measured at mean low water level, in square miles, are as follows:

The Lower Bay	124.30
The Upper Bay	20.74
Hudson River from the Battery to Mount St. Vincent	14.49
The East River from the Battery to Throgs Neck	15.20
Harlem River	0.70
Newark Bay	8.35
Kill von Kull	1.12
Arthur Kill	4.63
Jamaica Bay, excluding the Islands and hummocks	21.61

The total area of the above is 211.14 square miles. At a depth of 6 feet below mean low water, that is to say, if the water surface were lowered 6 feet, the area of the several divisions would be materially reduced. In other words if the area at mean low water is 100 per cent, then the area at 6 feet below mean low water would be 74.6 per cent. And, in the same way, if the water surface were lowered to 12 feet below mean low water, the water surface would be reduced to 58.6 per cent.

These figures show the shoaling of portions of the harbor, which is not shown on a chart or map. To put it in other words, looking at the map of the harbor, it would appear as if there was a very large body of water, which is correct as far as surface is concerned, but a very considerable portion of that surface is quite shallow, and if we could imagine the surface to be lowered, the water shown on such a map or chart would be contracted toward the channels, with the reduction in areas in per cent, as just stated. If you care for
1626 it I can give you the differences in the areas for the different divisions of the harbor at these different depths.

Q. I would like you to do so, Mr. Parsons?

A. For the sake of comparison I will repeat the areas given above for mean low water and will place opposite the figures for the two depths of 6 feet and 12 feet below mean low water.

Areas of Water Surfaces in Square Miles.

	Depths below mean low water		
	at M. L. W.	6 ft.	12 ft.
Lower Bay	124.30	106.20	83.60
Upper Bay	20.74	14.88	12.36
Hudson River Battery to Mt. St. Vincent	14.49	13.73	12.88
East River, Battery to Throgs Neck	15.20	10.30	8.54
Harlem River	0.70	0.47	0.38
Newark Bay	8.35	3.28	0.64
Kill von Kull	1.12	0.97	0.88
Arthur Kill	4.63	3.34	2.31
Jamaica Bay, Excluding Islands	21.61	4.40	2.20
	211.14	157.57	123.79
	100%	74.6%	58.6%

These figures if shown graphically on a map or chart would completely change the general appearance. For instance at the 6 foot depth, the Upper Bay would be very much contracted. Newark Bay would be diminished to a narrow strip. The Passaic and Hackensack Rivers would be just visible at their lower reaches. The bays and indentations of the East River east of Hell Gate would be almost lost, and Jamaica Bay would appear as a few streams or small rivers. At the 12 foot depth the Upper Bay would appear as a continuance of the Hudson River, to the Narrows. The Kill von Kull would show, but Newark Bay would be substantially eliminated.

The Hudson River would be somewhat narrowed. The East
1627 River would be considerably narrowed especially on the portion east of Hell Gate. Jamaica Bay would almost entirely disappear and the Lower Bay would be considerably contracted, especially along the Staten Island and Jersey shore.

Q. Mr. Parsons have you visualized the descriptions you have just given relative to the contractions of this body of water at the particular depths which you have testified to?

A. I have.

Q. And have you got a map or chart here now with you that so visualizes the descriptions that you have just given in your testimony?

A. I have.

Mr. O'Sullivan: I offer the map or chart which has been furnished by this witness and ask that it be marked Complainants' Exhibit No. 88.

The Commissioner: Received and marked Complainants' Exhibit No. 88.

Marked Complainants' Exhibit No. 88.

Q. Mr. Parsons, what is a tidal prism?

A. A tidal prism is the volume of water between high water level and low water level.

Q. Are the depths variable?

A. The depths of water in the harbor are variable. Of the aggregate water surface at mean low water, only about 58 per cent. has a depth of over 12 feet.

Q. How much water is there in the harbor?

A. The volume of water is variable from hour to hour, and the approximate mean volume is nearly the sum of the quantity of water below mean low water and one half of the mean tidal prism. The average quantity of water, therefore, is not far from the sum of 41,011,000,000 and 4,402,100,000 cubic feet or 45,413,100,000, exclusive of the lower Bay and Jamaica Bay.

1628	The average depth in feet below mean low water for the Upper Bay is	22.4 ft.
	The Hudson River, Battery to Mt. St. Vincent	30.7
	The East River Battery to 88th Street	31.7
	East River, 88th Street Old Ferry Point	22.3
	East River, Old Ferry Point to Throgs Neck	38.8
	Harlem River	9.7
	Newark Bay	6.6
	Kill von Kull	23.4
	Arthur Kill	13.1

Q. Mr. Parsons, is this water all changed in a tidal cycle?

A. It is not, only a small portion is changed at a tidal cycle.

Q. Will you please describe briefly the tidal actions?

A. The tidal actions in the harbor in brief are as follows: The tidal wave, progressing along the coast, causes a rise and fall of the water at the entrance to the Lower Bay. In the same way a tidal wave enters Long Island Sound at Montauk Point and reaches the end of the East River at Throgs Neck. The mean ranges of the tide at Sandy Hook and at Throgs Neck are not only different in height, but vary in time for high and low water periods. The result of these tidal waves is that the water flows into the harbor past Sandy Hook and also past Throgs Neck. The water in the harbor rises and falls in conformity with the water level changes of these tidal waves, and the tidal actions extend entirely through the East River, entirely through the Harlem River, up the Hudson River as far as the dam above Troy, through the Arthur Kill and the Kill von Kull, into Newark Bay, and up the Hackensack and Passaic Rivers to variable distances. And also flows in through the inlet at Rockaway Point, causing a change of water level in Jamaica Bay. As the tidal waves entering at Sandy Hook and Throgs Neck vary both in range and in time, there is caused an interference which materially changes the action of the wave, as it depends on some relation of these two waves one upon the
1629 other. In the same way the currents which are caused in the different parts of the harbor are made to flow in courses not always directly with the tide. For instance, the water running down the Hudson River at times runs around the Battery, and up the East River, and then conversely there are times when the water running down the East River runs around the Battery and up the Hudson River.

Q. How are the tidal currents produced, Mr. Parsons?

A. The tidal currents are produced either by the regular progressive wave motion, or by hydraulic conditions, that is to say the currents are due to the differences in water level existing at a particular time between two bodies which are connected, and third by a combination of these two. That is to say a combination of the regular tidal progressive motion and of hydraulic conditions.

Q. Can an estimate be made of how a floating object will be driven by these currents?

A. It is possible to make an estimate of how a particle would be

carried by the currents. It is done briefly as follows: The tidal currents normally follow very closely to the law of the curve of sines. If, therefore, the maximum velocity of the swiftest thread of the current is known it is possible to determine the mean velocity, which is nearly equal to the maximum velocity multiplied by 2, divided by Pi. Knowing this mean velocity, and the time, it is possible to predict approximately how a particle would be carried. There are certain causes which act to make this calculation approximate which are as follows:

The underrun at the time of tidal changes; second, the inertia of the floating stream when it changes from ebb to flood. Third, the shore currents are not the same as the channel currents. Fourth,
variations due to wind. Fifth, variations due to land water
1630 flow coming down the rivers from drainage areas above. Sixth, variations in tidal ranges. The paths of particles as predicted by these calculations have been found to be approximately correct, however, but the tendency is to make the paths a little more pronounced than probably will be found in practice or in actuality.

Q. If a particle is set adrift at Robbins Reef where will it go on these tidal currents?

A. If a particle is set adrift at the beginning of the flood it will be carried up the Hudson River to some point about 22nd Street, or perhaps up the East River to some point in the vicinity of Blackwell's Island. If the particle is set adrift at the beginning of the ebb it will be carried about half way down into the Lower Bay and then will meet the flood tide and will be carried back.

Q. Mr. Parsons, in response to my last question did it relate to any particular area of these water surfaces or to all of them?

A. It related to the path which the particle would travel if the particle remained in the main channel. That is to say the particle is assumed not to be driven out by any of the causes which I have mentioned previously, from the main channel flow of the harbor, and the particle will in that way travel the Upper Bay the Hudson River or the East River at will. There is no law as to which river it would take in its upward passage, and on the succeeding ebb tide it would come back again into the Upper Bay and so move forward and backward until finally it went through the Narrows into the Lower Bay and probably in time would gradually be carried towards Sandy Hook. No other parts of the harbor were considered in my answer.

Q. Mr. Parsons have you charted the course described by you as likely to be taken by particles such as you have described in your testimony?

A. I have. I made two diagrams showing in the first dia-
1631 gram how a particle would be carried if set adrift off Grants Tomb in the Hudson River, and have plotted its forward and backward movement on the ebb and flood tides. This diagram would show the answer to your last question.

On another diagram I have plotted where a particle would be carried if it were set adrift in the East River off College Point.

First, on the beginning of ebb and secondly on the beginning of flood. In the East River, I mean by ebb the current which flows from the Sound to the Upper Bay, and by flood the current which flows in the contrary direction from the Upper Bay to the Sound. This second diagram shows that if a particle is set adrift in the East River it has a tendency to remain in the East River, which was substantiated very beautifully by a float which was followed day and night for nearly four days, some three and one half days, and never passed further south than the Brooklyn Bridge, and never passed further east than Whitestone Point.

Mr. O'Sullivan: I offer in evidence the chart produced by this witness marked Surface Currents Movements during Successive Tides through the Hudson River and ask that it be marked in evidence as Complainants' Exhibit No. 89.

The Commissioner: Received and marked Complainants' Exhibit No. 89.

Marked Complainants' Exhibit No. 89.

Mr. O'Sullivan: I also offer the chart or diagram produced by this witness describing the surface current movement during successive tides through the East River and ask that it be marked in evidence as Complainants' Exhibit No. 90.

The Commissioner: Received and marked Complainants'
1632 Exhibit No. 90.

Marked Complainants' Exhibit No. 90.

Q. In your testimony, Mr. Parsons, you referred to a float, a series of float observations, which covered several tidal cycles, and which you say corroborated the views that you expressed in your testimony. I hand you Complainants' Exhibit No. 87 and ask if the float observations that you included in your testimony are plotted upon that exhibit?

A. It is.

Q. What is the excess of the ebb over the flood volume at the Narrows in the Hudson River in the East River and in the Kill van Kull?

A. The excess of ebb over flood at the Narrows is 1,262,400,000 cu. ft. In the Hudson River opposite West 39th Street 1,087,200,000 cubic feet. The East River at Brooklyn Bridge about 80,000,000 cubic feet. The Kill von Kull opposite New Brighton 88,200,000 cubic feet.

Q. Mr. Parsons can sea and land water be divided so as to estimate the quantities of each?

A. They can.

Q. Does all the water discharged through the Narrows on the ebb tide go to the Atlantic Ocean?

A. It does not. Some of the water discharged through the Narrows on the ebb returns on the succeeding flood, and this proportion so returning is a considerable proportion of the total volume flowing through the Narrows on the ebb.

Q. Have you made calculations estimating the relative quantities of sea and land water?

A. I have.

Q. Now, taking the large volume of water in the harbor, is the flushing out of the harbor accomplished each tide?

A. It is not. Only a small portion of the total water in the harbor passes out at each ebb tide. The water which passes out at an ebb tide is by no means all the water in the harbor and of that
1633 portion which does pass out a large proportion returns on the next flood. There is, however, a gradual trend toward the ocean. That is to say, the water in the harbor has a tendency to pass out through the Narrows towards the sea and that tendency is caused entirely by the land water coming down the rivers from the water sheds above.

Q. When is this flushing out of the harbor greatest, and when is it least?

A. The flushing out of the harbor is greatest during those periods when the land water coming down the rivers is in the greatest quantity. That is to say when the run-offs from the water sheds above are greatest.

Q. And when is it least?

A. It is least at those times when the discharges of the rivers are at a minimum. That occurs during the dry months.

Q. Will you briefly describe the flushing action of the flood and ebb tides that you have included in your testimony?

A. The flushing out of the harbor by the action of the tides is not great. Although large volumes of water flow past the Narrows on both the ebb and the flood tides, almost as much water comes back on the flood as is passed out on the previous ebb. It is the difference in volume, or the excess of ebb over flood that alone measures the seaward trend of the harbor waters. This excess or the resultant flow is about 11 per cent. of the mean volume of ebb and flood. This excess or resultant flow is obviously the amount of land water coming from the rivers, nothing else, except a small quantity from the East River. This latter condition is self evident. If it were not so, then the flood volume must equal the ebb volume or the water level in the bay would not come back to the same level at each normal tide. When the land water discharged from the rivers is large, the resultant is also large. This occurs in April when the temperatures are low. Conversely when the discharge of
1634 land water is small, the resultant is also small. This occurs in August when the temperatures are high. When the land water is small more water comes in from the sea to maintain the equilibrium or balance. Conversely when the land water is large, less water enters from the sea. Of the land water which passes out through the Narrows on an ebb, some returns again on the next flood. This proportion which returns is about 72 per cent. of the whole amount of land water going out on the ebb. To replace the amount of land water passing out which does not return, sea water comes in on the next flood. The land water passing out is not clean fresh water, but water which has come down the rivers carrying its quota of river filth and increasing this burden by washing the shores of Weehawken, Hoboken, Jersey City, Communipaw,

Bayonne, Manhattan, Brooklyn and a part of Richmond. The true flushing action of the harbor is therefore either the land water discharged or that portion of the land water which does not return on the next flood plus that portion of the sea water which enters on the flood which was not in the harbor on the preceding tide. These quantities are small compared with the volume of the tides. The former is 35 per cent. and the latter 28 per cent. of the normal volume of ebb discharge through the Narrows.

Q. Mr. Parsons have you arranged these tidal actions in the form of a brief report, these tidal actions that occur in the harbor of New York?

A. I have taken all the salient points and arranged them in the form of a brief report, which I have before me.

Q. And in which you have visualized the percentages of salt and land water at the various times and stages that you have described?

A. I have.

1635 Q. Have you got a copy of that report with you?

A. I have the original.

Q. The original?

A. Yes, sir.

Q. This is your own work?

A. It is.

Mr. O'Sullivan: I offer in evidence this report and ask that it be marked Complainants' Exhibit No. 91.

The Commissioner: Received and marked Complainants' Exhibit No. 91.

Marked Complainants' Exhibit No. 91.

Mr. McCarter: I object to this as being so far as appears a mere compendium based upon data that have been assumed by the witness and as being irrelevant and incompetent.

The Commissioner: Note the objection.

Q. As the basis to this report on the tidal actions in the harbor of New York, which has just been marked in evidence, Mr. Parsons, how did you obtain your data; how did you prepare your report, on what facts?

A. The report which has just been offered in evidence, contains the salient features regarding the tidal phenomena, in the Harbor of New York as worked out after nearly four years of continuous study, during which all observations were carefully studied and interpreted since 1858. All the records of the United States Coast and Geodetic Survey were offered for my use and my work was carried on with the aid of all the observations which were made by the Metropolitan Sewerage Commissioners. The result being that my work, as based on the Metropolitan Sewerage Commissioners' inspection, resulted in a close agreement with those made by the United States Coast & Geodetic Survey from observations of their own.

The report contains the general characteristics of the harbor, the velocities of the currents in different places in
1636 the harbor, and the duration of the surface currents for both ebb and flood. The currents flowing in the harbor at each

lunar hour, the accuracy of which was worked out in a diagram which is also in the report. It contains the volumes of water flowing on ebb and flood, and the original calculation sheet. It contains a summary of the salinometer records which were made at eleven different stations by the Metropolitan Sewerage Commissioners, during twelve months of the year 1909, the observations being taken at a number of times each day. It contains the division of sea and land water in the ebb and flood currents at the Narrows, Hudson River and the East River. These results are shown both in tabular form and graphically. The graphic diagrams show very clearly that during the dry season of July, August and September, the amount of sea water which will return is greatly in excess of the same during March or April. It substantiates what I have said before, namely, that the best flushing effect is obtained when the river discharges are at their maximum. On the flood currents it shows the amount of new sea water which comes in, and by new sea water is meant not necessarily new clean sea water, but sea water which was not in the harbor on the preceding tide. The truth of that is well substantiated in the float experiments which were made by the Metropolitan Sewerage Commission, many of which show loops and places where the floats would remain in the Lower Bay for a long period, while the tidal floods were progressing, and then would finally work their way back towards the Narrows, after having lost a part of a tide. The report as offered in evidence is self explanatory. I do not know of any point that needs
1037 particular amplification at this moment.

Q. And you are still a member of the Metropolitan Sewerage Commission, Mr. Parsons?

A. I am.

Mr. O'Sullivan: Your witness.

Cross-examination by Mr. McCarter:

Q. What was your chair, Mr. Parsons, at the Rensselaer Polytechnic Institute?

A. I lectured on engineering subjects and am known as Professor Emeritus, with the title of Professor Emeritus of Practical Engineering, and my subjects cover a variety of matters which are generally mapped out by the faculty so as to substantiate at the end of the year the work they have been teaching the classes during the year. I go up in the Spring or along about May or the last of April, and I confirm what the professors have been telling the classes theoretically, by showing them the practical work that is actually being done throughout the world.

Q. Previous to your studies of New York Harbor with reference to your membership in the Metropolitan Sewerage Commission, what hydraulic work had you performed or done?

A. I have done considerable work for private parties, banks, and trust companies in hydraulics. I built the water works of the City of Stevens Point, Wisconsin. In examined the water supplies for

a number of cities. I built the Spiers Falls Dam on the Upper Hudson with an electric development of about 30,000 horse power. I put in water power plant back of Whitehall. I have examined a number of rivers and water powers for the International Paper Company and others.

Q. New York Harbor is rather unique, is it not?

A. It is in certain respects very unique, when compared with other tidal harbors of the world on which large communities are situated.

1638 Q. In what does that uniqueness consist?

A. It consists first of the small range of tide existing at New York in comparison with other harbors on which large communities are riparian, as for instance London or Hamburg. Also the land locked Upper Bay and Newark Bay, which are large bodies of water as regards their surface area. The characteristics which belong to the East River—being as I said before, a strait and not a river—and the same characteristics apply to the Kill von Kull and to the Arthur Kill.

Q. Why did you, in making pictures, and in estimating the area of the water surfaces of the several divisions of the harbor select the depth of 6 feet and 12 feet respectively below mean low water?

A. I did that for my work in connection with the Metropolitan Sewerage Commission. We took depths of water 6, 12 and 18 and 24 feet, and charted them out as I have done, and it has been offered in evidence this morning for the two depths 6 feet and 12 feet. The object was to study the harbor in all its phases. The tidal phenomena chiefly follow the flow of the channels, although somewhat modified naturally by the configuration of the water surfaces—the surfaces which exist between mean low and mean high water.

Q. You have given the percentages at 6 feet and 12 feet below mean low water respectively as 74.6 and 58.6 if I am right; is that the percentage of the sum or the percentage that each level bears to the 100 per cent. at each particular division of the harbor?

A. That is the percentage of the sum. In other words, the sum of the surfaces at mean low water is 211.14 square miles, while the sum of the surfaces, if the water level was reduced to 6 feet below mean low water, would be 157.57 square miles. This latter figure is 74.6 per cent. of the former.

Q. Have you estimated the percentage in the case of the

1639 Upper Bay?

A. I have not, but I can give it to you, for the figures are right here.

Q. Will you please do so?

A. For the Upper Bay the percentage at a depth of 6 feet below mean low water would be 71.7 and for a depth of 12 feet, would be 59.6.

Q. I understood you to say that the approximate mean value of the water in the harbor is the quantity below the mean low water

level plus one-half the tidal prism; is that an estimate based upon some mathematical formula, or how is it ascertained?

A. You do not mean the value but the volume.

Q. The volume?

A. That is self evident. The water below mean low water level is in the harbor at all times. The water in the tidal prism is the volume which changes. Now, the water in the harbor at any time is the water below the mean low water level plus that portion of the tidal prism which is in the harbor at the time under consideration. I was asked for the mean volume of water, and I therefore took half the tidal prism and added that to the water below mean low water level. I understand that that condition does not exist, because the tidal prism is never half filled at all parts of the harbor at once, which is caused by the difference in time when high water is reached at Sandy Hook and Throgs Neck. The times there are sufficiently far apart in hours so as to prevent the harbor, in all its branches being half full of tidal water at the same time.

Q. Well, take the Upper Bay and the Lower Bay. Have you separate estimates of their quantities of water at full tide and at half tidal prism, without regard to Jamaica Bay and Throgs Neck?

A. I have.

1640 Q. Please give them, first, at full tide and second at one-half the tidal prism?

A. In the Upper Bay the volume below mean water level is 12,970,000,000 cubic feet. The tidal prism of the Upper Bay is 2,541,000,000 cubic feet. Therefore in the Upper Bay the quantity of water, when the tide is half up or half down is one half this latter figure added to the former figure.

Q. Now, I think you may give the same with regard to the Lower Bay, if you can?

A. No, I cannot give it to you, for the Lower Bay because I did not work it out. I can give you the tidal prism of the Lower Bay.

Q. What is that?

A. The quantity of water in the Lower Bay below mean low water, I did not work out for the reason that parts of it are so directly open to the Atlantic Ocean that it was not necessary for my work to do it. But it is perfectly feasible to do it, and the way is which it would be done would be this:

Taking a chart of the Lower Bay and determining the mean depth. The simplest way for which would be dividing it up into squares and getting the average depth in each square and then from them finding the average depth for the whole Lower Bay. I have already given the area of the Lower Bay and multiplying this area by the average depth would give the quantity of water which would be in the Lower Bay below mean water level. It would make, of course, a large figure.

Q. What is the tidal prism of the Lower Bay?

A. The tidal prism of the Lower Bay at a range of 4.7 feet would be 16,300,000,000 cubic feet.

Q. Now, Professor, without asking you to be anything like

accurate, are you able to make an estimate from the size
1641 of the tidal prism or your knowledge of the Lower Bay of the quantity of water below the tidal prism that is contained therein?

A. The Lower Bay is approximately 6 times larger than the Upper Bay in area, and if it had the same average depth the volume below mean low water would be six times greater than that of the Upper Bay. That is to say, approximately 77,000,000,000 cubic feet, but I do not want to be held to that as accurate, that is a mere estimate.

Q. Yes, I understand that. As a matter of fact the Lower Bay has if anything, a greater depth, is not that so, than the Upper Bay?

A. No, I do not think that it would average a much greater depth. The Lower Bay extends to the west or to the south of Staten Island and that water is comparatively shallow, and is, roughly speaking, the mouth of the river which enters at that point. It does not affect the tidal actions that occur in and through the Narrows. The Lower Bay has been artifically dredged in a number of places, forming channels. The bar of the Lower Bay, or the edge towards the Atlantic Ocean was normally quite shallow, but the harbor improvements have dredged through this bar a number of channels which are maintained at about 35 feet in depth below mean low water. The socalled pot-holes or places of extraordinary depth do not occur largely south of the Narrows, and the reason of that is self evident, because where the water is throttled in passing through the Narrows, which are quite narrow, being only about one mile in width, the area passing the volume of water, is made up by greater depth, while across the bar at Sandy Hook the width is so wide that the depth is comparatively shallow, and it still can pass the enormous volume that does pass that point on each ebb and flood tide.

Q. Do you include the Raritan Bay in the Lower Bay?

A. Yes, Raritan Bay is part of the Lower Bay. It is also
1642 part of that indentation of the coast into which the Shrewsbury enters. Do you want me to define the limits of the Lower Bay?

Q. Perhaps it would be well, yes.

A. The Lower Bay is taken as that water surface which is bounded by Staten Island, a line across the Narrows from a point about half a mile below Fort Wadsworth Light to the point on the Brooklyn shore south of Fort Hamilton reservation around Gravesend Bay, Norton's Point, Coney Island, to Barren Island, by a line from Barren Island to Rockaway Point. From Rockaway Point to the Hook Beacon off Sandy Hook. Around Sandy Hook to the Port Light at Spermaceti Cove, then southwesterly to the Highlands. Along the New Jersey shore, from South Amboy to Ferry Point across the mouth of the Raritan River, across the mouth of the Arthur Kill from Ferry Point to Staten Island and back along the south shore of Staten Island to the place of beginning.

Q. Do you consider the Raritan River a tributary of New York Bay?

A. It is tributary to Lower New York Bay.

Q. And in estimating the amount of land water in New York Bay have you given credit to the natural flow from the Raritan shed?

A. No, because it does not affect the Upper New York Bay. In other words, the land water coming down was taken as the drainage into New York Upper Bay, because that is the only part which affects this subject.

Q. Are the Narrows within the Lower or Upper Bay?

A. The Narrows are taken as in the Upper Bay. The exact definition of the Narrows has never been defined, but it is referred to as that strait between Richmond and Brooklyn and is taken as part of the Upper Bay.

1643 Q. The flood tide, I presume, goes up the Arthur Kill as well as through the Narrows?

A. It does.

Q. Have you made allowance in your figures for that?

A. I have.

Q. What proportion reaches the Upper Bay through the Arthur Kill or the Kill van Kull of the flood that you have credited to the Upper Bay?

A. Your question is put a little ambiguously from my view point, but to explain, the tidal action in Newark Bay is such that about 84 per cent. passes out through the Kill van Kull into New York Upper Bay and about 16 per cent. through the Arthur Kill. On the succeeding flood tide, those proportions are repeated. That is to say Newark Bay is filled by about 84 per cent. coming through the Kill van Kull and 16% coming through the Arthur Kill.

Q. Well, some comes into the Upper Bay also, I imagine, some of the flood from the Newark Bay?

A. The ebb from Newark Bay passes in to the New York Upper Bay in the proportion just stated, that is to say about 84% through the Kill van Kull.

Q. Well, does the Upper New York Bay get any flood tide through the Kill van Kull?

A. The flood tide through the Kill van Kull passes from New York Bay into Newark Bay and the ebb tide through the Kill van Kull from Newark Bay into the New York Bay. There is no flood tide from the ocean through the Lower Bay, through the Arthur Kill, through the Kill van Kull and into New York Bay.

Q. Where do the flood and ebb meet or where is the zone of influence of the flood from the Lower Bay up the Arthur Kill?

A. It varies a little from the ranges of tide existing, but approximately at Elizabethport at the northern mouth of the Arthur Kill.

Q. Now, you have spoken of some interference at or near
1644 I think you said Throgs Neck, between the flood coming above from the Sound, and the flood coming up through the East River. Have I put that right?

A. That is right. The range of tide at Throgs Neck is different

from the range of tide at Governors Island. The hours at which high water is reached at these two places are different.

Q. What is the difference in time and the difference in range between Governors Island and Throgs Neck?

A. At Governors Island, the normal tide range is 4.4 feet, while at Throgs Neck the normal range is 7.3 feet. When high water occurs at Willetts Point or Throgs Neck, the tidal wave enters three hours and five minutes later than the tidal wave at Governors Island. The two tides meet and cross or overlap at the Hell Gate, and, since they differ in time and heights, cause contrasts of water elevations, which call into existence the violent currents.

Q. Is the tidal prism at Governors Island affected in any way by the influence of which you have spoken at Throgs Neck?

A. The influence of the interference is traceable to Governors Island,——

Q. Appreciably?

A. Where it is lost. The result is appreciable. It is because of this interference that the range of tide at Governors Island is less than the range of tide at Sandy Hook. This reduction in range is also somewhat caused by the spreading out of the incoming tide over the surfaces of New York Bay and Newark Bay, after having passed through the narrow passage at the Narrows. Those two influences working together cause a lesser range of tide at Governors Island than at Sandy Hook.

Q. What is the difference?

A. It is approximately 3-10 of a foot.

1645 Q. You have spoken of the course of particles of water and of the prediceted progress of particles in the water and their predicted progress. Has that progress as testified to by you, irrespective now of any confirmation that you find in measurements or floats taken by other people, has that been calculated according to this formula that you spoke of, or is the progress as you defined it the result of observation?

A. The progress or paths of a particle floating in the water as prepared by me on some diagrams which were admitted in evidence this morning, were calculated independent of any observations which were made by floats by me or by others. The calculations on the original sheets are before me and the principle was briefly as follows:

The velocity of the current at strength was laid off in a column opposite each mile. This velocity was then multiplied by the length of time during which the surface currents flowed on the ebb, and the product was again multiplied by two divided by Pi, in order to reduce the result to a mean. The same process was repeated for the flood tide. The result was the formation of a table giving in columns opposite the respective miles the distances which a particle would be carried on the ebb or flood. Then, taking some point and setting a particle adrift the average distances through which the particle would be carried were determined from the table just mentioned and plotted. The same process was then repeated for the succeeding tides with the result that the diagram was produced which has been offered in evidence.

Q. Your ascertainment of the mean by means of the formula was for the purpose of getting the progress at mean depth?

A. No, not strictly speaking at mean depth, but at what is known as the surface current. That is to say the velocity of the
1646 water just below the true surface, but not necessarily at mean depth.

Q. Then practically the velocities that you have taken are surface velocities?

A. They are.

Q. And the particles are assumed to be at surface as you have defined it?

A. The particles are assumed to *be* have the velocity of the water just below the surface.

Q. Where did you get the formula that you used for that ascertainment?

A. The formual is self evident in its construction. The tidal actions are harmonic in character, when they obey the law of the true progressive wave motion. When the water obeys the laws of the hydraulic conditions they approximate to those same harmonic conditions. The harmonic conditions are represented by the sinusoid. The law of this curve is that its mean height is equal to its maximum height, multiplied by two and divided by Pi. Now, it is self evident that if we find the mean velocity at which a particle is being carried by the water and multiply it by the hours, the result will be the distance which that particle would be carried in that time, and that is the simple process which was used in plotting those diagrams.

Q. What then is the average distance that a particle starting, we will say at Robbins Reef in the Upper Bay would travel on the ebb tide, with the normal land water current?

A. It would travel southward according to the estimate approximately 10 miles on the ebb tide.

Q. That would take it where?

A. That would take it down into the Lower Bay.

Q. Of course it would, but how far down in the Lower Bay—where would 10 miles from Robbins Reef be about, near what?

A. If it traveled in a straight course it would be some point about north, northeast from Sandy Hook Point.

Q. About how far from Sandy Hook Point?

A. That is very difficult to predict on account of not know-
1647 ing just through which channel the particle might elect to go. The results of observations show that as stated by me before—that these paths predicted for the travel through the Narrows south into the Lower Bay exceed the distance actually traveled by particles in the water. The observations also show that the paths which particles travel are not duplicated by other particles on succeeding tides, but some elect to go into Gravesend Bay and stay there for hours, and then others will pass by Gravesend Bay and go to some point off Sandy Hook, and some will go towards Sandy Hook, but a lesser distance, and some have shown a tendency to fol-

low the southern shore of Richmond towards the middle of the Lower Bay, and appear to want to avoid the main channels.

Q. These observations to which you have just referred, I assume, are not your own observations, but what you learned from others?

A. These were almost entirely on my own observations. That is to say, the observations made by me through the Metropolitan Sewerage Commission.

Q. You understand that observations that other people make are not your observations. I ask you whether the observations referred to in your last answer were personal observations or things that you heard from other people?

A. I just answered you sir, that the observations were made to which I referred, by me and under my direction and were actually carried out by men employed through the Metropolitan Sewerage Commission.

Q. This predicted or estimated progress of particles you have assumed I believe, to be entirely independent of the 6 or 7 elements that you say may cause trouble?

A. Yes, sir.

1647½ Q. As a matter of fact, therefore, by reason of the existence of these 6 or 7 trouble makers, the predictions are to that extent, subject to variations, are they not?

A. They certainly are. A particle might travel as predicted, or it might be driven from its predicted course by some or a combination of some of the elements which I have already mentioned.

Q. By "particle" what do you mean in your testimony?

A. By the word "particle"?

Q. Yes.

A. I mean any substance which would float or stay in the moving current and not sink and go to the bottom or float so high as to be directly affected by the wind.

Q. I suppose particles, have, however, varying specific gravities, which would also cause a variation in the result?

A. Particles certainly do have difference in specific gravity, and some are so light that they would float so high on the surface of the water as to be blown by the wind rather than be carried by the current, and then other particles might be so heavy as to sink at once to the bottom. The specific gravity of the particles I am considering is practically unity. That is to say the same as the water. Once put into the current, it would flow with the current at a point just below the surface.

Q. I judge from your statements that you have had made under your direction in connection with the Metropolitan Sewerage Commission several float experiments of the action of the tide from the upper to the lower Bay?

A. Yes, sir, a number of float experiments were made, some 70 of them.

Q. I do not know that I quite understand what the excess of the ebb over the flood is. Is that the land water, the land current?

A. It is. The ebb tide in volume exceeds the flood tide in volume by the discharge of the land water from the rivers. If that were

not the case, the bay would gradually fill up, but as the mean
1648 height of the water in the harbor, the Upper Bay, for example, stays at the same level, year in and year out, the water coming down from the rivers of which of course the Hudson is by far the largest, passes out on the ebb tide through the Narrows and it is that discharge of the rivers which makes the ebb flow greater than the flood flow.

Q. Well, now, the particles that you have been speaking of that are carried along with that excess of course do not return, I presume?

A. Of the land water which passes out on the ebb tide, a proportion returns again on the succeeding flood tide. All the land water which passes on one tide does not go to sea, but some of it comes back again.

Q. But such as does not go back again carries with it of course the particles that went along with it?

A. That is correct.

Q. Is there any known method of ascertaining how much of the land water that goes down on the ebb comes back with the flood?

A. There is.

Q. How is that ascertained?

A. That is ascertained by taking the measurement of the specific gravity of the water. In other words, using an instrument known as the salinometer. The water in the harbor, the Upper Bay, is salt but not as salty as the sea, and the reason that it is not as salty as the sea is that it contains a certain proportion of land water. Now, for every month in the year, a record was kept of the quantity of land water which will return, of land water which will not return, of sea water, which will return, and of sea water which will not return. They were worked out for different points of the harbor, including the Narrows, and submitted in the brief report which I have prepared and has been already admitted into evidence.

1649 Q. Well, the estimated amount of land water that will return was ascertained by means of these experiments with the salinometer to test the quantity of salt in the water at different stages of the tide, ebb and flood?

A. Yes. They were not in the sense of experiments. They were actual measurements. The measurements were made three or four times a day at stated intervals, at 11 different stations throughout the harbor, and were carried out continuously during the year 1909, and that continuous record gave a complete knowledge of the salinity of the waters at these different points. The information collected in that way was used to divide the tidal volumes up so as to show the land later and the sea water which will return and which will not return, and in the report the same results are given graphically as are given in tabular form.

Q. Who conducted those tests or what I call experiments?

A. They were made by the Metropolitan Sewerage Commission.

Q. And by a series of observations extending over the whole of 1909?

A. The observations started in September 1908, and they were continued for about fifteen months. September, October, November

and December 1908, were looked upon as the beginning of the work, and it was found that the work was progressing so well and accurately that it was decided to continue it through the whole year, and so they started on the first of January 1909, making a continuous record for the whole year ending on December 31st.

Q. Now, those tests were conducted in what way, just describe a day's work?

A. A salinometer is an instrument, which measures the specific gravity of a liquid. The Metropolitan Sewerage Commissioners finally designed a salinometer which was serviceable, strong and accurate. It contained a bulb which permitted the instrument
1650 to float, a graduated scale, which would read the depth at which it was floating and a thermometer which would record the temperature of the water. These instruments were all manufactured for the Metropolitan Sewerage Commission and tested as to accuracy. There were established eleven different stations and their readings were made at regular intervals at each one of those stations and the records all kept. The readings were then reduced to the standard temperature of 60 degrees Fahrenheit, which is the customary figure for this class of work. The figures of specific gravity were then interpreted to mean certain percentages of salt water, and naturally the balance was fresh water. In order to check the results, samples of water were taken and tested in the laboratory for chlorine, and the results of the laboratory analyses checked very closely with the actual readings as given by the salinometer.

Q. Where were these eleven stations—were they all in the Upper Bay?

A. Oh no, the eleven stations are situated——

Mr. O'Sullivan: Before the witness answers that question Complainants' Counsel desires to inform Counsel for the Defense that he will produce the men who actually conducted these experiments and made the determinations at a latter stage in the case.

A. The stations were as follows:

Ambrose Light Vessel,	Great Beds,	West Bank,
Fort Wadsworth,	Robbins Reef,	Governor's Island,
Passaic Light,	Throgs Neck,	Blackwell's Island,
Ft. Washington Point,	and	Tarrytown.

1651 Q. Have you the results before you at Robbins Reef?

A. I have a summary of them before me, of the results at Robbins Reef.

Q. Are they in this report?

A. They are not in the report which has been admitted in evidence in the form in which you ask. The results as far as affecting the currents passing through the Narrows are there, but not specifically Robbins Reef.

Q. What summary have you here indicating the results of your observations at Robbins Reef, with regard to the specific gravity or quantity of salt?

A. I have before me the results of the observations made at Robbins Reef station for every month during the year 1909, giving the temperatures, maximum and minimum, and the specific gravities, maximum and minimum, and average, and a record of the results averaged up for every 5 days. That is to say from the 1st to the 5th of the month, instead of the actual three readings on every day. You see at Robbins Reef there were three readings every day and there are 365 days, so there are some thousand readings that were made there. Now, I have before me an abstract of that result, but condensed.

Q. Suppose you give us the maximum, minimum and average specific gravity at Robbins Reef in each month during the year 1909?

A. For sixty degrees Fahrenheit the results were:

January, 1909.

Specific gravity, maximum..... 1.0229
Specific gravity, minimum..... 1.0149
Specific gravity, average..... 1.01873

1652

February, 1909.

Specific gravity, maximum..... 1.0209
Specific gravity, minimum..... 1.0059
Specific gravity, average..... 1.01390

March, 1909.

Specific gravity, maximum..... 1.0201
Specific gravity, minimum..... 1.0090
Specific gravity, average..... 1.01428

April, 1909.

Specific gravity, maximum..... 1.0161
Specific gravity, minimum..... 1.0075
Specific gravity, average..... 1.01098

May, 1909.

Specific gravity, maximum..... 1.0157
Specific gravity, minimum..... 1.0080
Specific gravity, average..... 1.01144

June, 1909.

Specific gravity, maximum..... 1.0197
Specific gravity, minimum..... 1.0123
Specific gravity, average..... 1.01650

July, 1909.

Specific gravity, maximum..... 1.0222
Specific gravity, minimum..... 1.0156
Specific gravity, average..... 1.01960

August, 1909.

Specific gravity, maximum	1.0224
Specific gravity, minimum	1.0167
Specific gravity, average	1.01963

September, 1909.

Specific gravity, maximum	1.0249
Specific gravity, minimum	1.0189
Specific gravity, average	1.02038

1653

October, 1909.

Specific gravity, maximum	1.0250
Specific gravity, minimum	1.0180
Specific gravity, average	1.02007

November, 1909.

Specific gravity, maximum	1.0220
Specific gravity, minimum	1.0184
Specific gravity, average	1.02007

December, 1909.

Specific gravity, maximum	1.0226
Specific gravity, minimum	1.0159
Specific gravity, average	1.01940

Redirect examination by Mr. O'Sullivan:

Q. The salinometer records which Mr. McCarter has asked you relative to, were these salinometer records made as you described at 60 degrees Fahrenheit, were they used as a basis of these charts, these colored charts in Complainants' Exhibit No. 88?

A. They were.

Q. Mr. McCarter asked you some questions relative to surface velocities. How deep does the surface velocity take of the column of water?

A. It varies at different stages of the tide, but when the tide once gets running in a given direction, the velocity at the surface extends down to a considerable depth. In some places where the channels are straight and fairly smooth along near the banks, it probably extends almost to the bottom. In other parts of the harbor owing to roughness along the bottom and the high velocities which are reached, the water rises from the bottom at times toward the top. At the same time the surface water goes down towards the bottom. Such phenomena are very closely seen at and near Hell Gate on the East River. When the tide turns from ebb to flood, it usually

1654 turns on the bottom first neglecting for the moment any side currents at the shore—and the change takes place from the bottom up. Then, after the tide once gets going on flood up a

straight reach like the Narrows, the surface velocity probably extends down nearly to the bottom.

Q. The surface velocity taking it in the main channel would reach at a minimum what depth?

A. That is a little hard to answer.

Q. Approximately?

A. Hard to answer definitely owing to the inertia of the water moving in the ebb tide, the surface velocity has a tendency to flow long after the current has changed at the center of the section, so that at the end of the tidal period, or the beginning which ever you consider it, the surface velocity does not extend so far in depth. After the current is once well established, the velocity would be practically the same at a quarter, half, perhaps two thirds of its depth, as at the surface.

Q. But in employing the term "surface velocity" what I want to get at, Mr. Parsons, is whether you merely include a few inches of the surface of the water, or whether under all conditions, it extends for some feet?

A. My use of the term "surface velocity" was somewhat in the nature of a scientific term. The velocities and the times during which a current flows has been determined by the water at the surface or just below the surface, and, therefore, in a scientific way, we speak of it as surface velocities. Now, as I have just said, after the tidal current is once established in those straight runs through the harbor, like the Narrows, the velocity found below the surface at considerable depth, one third, one half, or two thirds, depth
1655 is practically the same as at the surface. But there are causes which come in at the side which affect it, like piers or irregular shores. They show a difference.

Q. So that in employing the term "surface velocity" you may mean anything from a few feet from the surface downward to the entire depth of the water moving?

A. Not to the entire depth, because the water running along the bottom is held back by the friction, but in a big body of water like the Lower Bay or the Hudson River, after the current is once well established, the surface velocity is found at considerable depths, say one half or over. But, as I said before, it varies, owing to the oscillating movement of the flood and ebb.

Q. But is it under any conditions confined to the upper surface or a few inches below the upper surface?

A. Only just at a period while the tide is turning from ebb to flood, a short time at the beginning, when the water at the surface will be running ebb, while the water at a depth will be running flood.

Q. The predicted course for particles as visualized in Complainants' Exhibit No. 90, were these verified by float observations that had been plotted on charts by the Metropolitan Sewerage Commission?

Mr. McCarter: I object to it as calling for a conclusion.

The Commissioner: Note the objection.

A. Some of the float experiments which were made by the Metropolitan Sewerage Commission, closely substantiated the theoretical paths as shown on the exhibits.

Recross-examination by Mr. McCarter:

Q. Mr. Parsons, do I understand that what you have characterized as surface velocities of a current of water, that that is
1656 synonymous with what is known in hydraulics as mean velocity?

A. Oh, no.

Q. What is known in hydraulics as mean velocity?

A. The mean velocity of water through a cross section is the average velocity of the different particles passing through that section at a given time.

Q. In recognition of the fact that the rate or speed which it gives particles at different heights on the plane, it varies?

A. That is correct and not only in height, but in positions, horizontally.

Q. For instance, of course, water, like everything else, goes more rapidly along the lines of least resistance, and of course, particles of water float over other articles of water more quickly, than when they are near by the shore; so that their progress would be interfered with by the land, so that the speed of the current in the middle and near the top of a given plane, would be greater, would it not, than near the shore or near the bottom?

A. That is correct. The maximum velocities are generally found at some distance below the surface and in the middle of the section.

Q. And is it not a recognized fact in hydraulics that in order to get this so-called mean velocity from the observation of floats they have to be placed and continued in that relative position which will be nearest to the average or mean speed, rather than the surface or the shore or the bottom speed?

A. That is true to a certain degree. In gauging a stream sometimes measurements of velocity are made at different points in the section. Sometimes that method is not convenient, and the surface velocity is measured and the mean velocity is determined by multiplying the observed surface velocity by a co-efficient, and in streams
of water as large as we have them in the Harbor of New
1657 York, the opportunity of actually measuring by simultaneous gauge readings is not permissible. It would interfere too much with the navigation. Therefore, the only way is to observe the velocity by floats or similar means; the depths at which the floats are controlled being made variable.

Q. In these predicted speeds of particles contained in your evidence, has there been any allowance for the use of the co-efficient?

A. It was not necessary.

Q. I did not ask you that. I asked whether there had been any allowance for the use of co-efficients in ascertaining the mean velocities?

A. The co-efficient there was 2 divided by Pi, which is the ratio

een the maximum velocity and the mean velocity of a harmonic
e, and the velocities are based as I said, on the assumption that
water is obeying the harmonic law, the curve of sines, which
ry nearly true.
. I suppose there is a difference between the surface and mean
cities in New York Harbor and in the Upper Bay as is in any
r body of water?
. Yes, there are decided differences because the mean velocity
s into consideration the velocity of the water near the bottom
near the shores, and the co-efficient used in determining that
iven in that brief report which has already been handed in in
ence.

t 2:30 P. M. adjourned until further notice from the Com-
ioner.

Supreme Court of the United States, October Term, 1911.

THE PEOPLE OF THE STATE OF NEW YORK, Complainants,
against
E STATE OF NEW JERSEY and THE PASSAIC VALLEY SEWERAGE
COMMISSIONERS, Defendants.

CITY HALL, NEW YORK CITY,
May 15th, 1912—10:30 a. m.

Present: James D. Maher, Esq., Commissioner.

Appearances:

Dr. Wm. J. O'Sullivan, Special Counsel for the People of the
te of New York.
Robert H. McCarter, Esq., Special Counsel for the State of New
sey.

Pursuant to the following order, the hearings are resumed in the
amber of the Board of Aldermen, New York City Hall.

Supreme Court of the United States, October Term, 1911.

No. 4. Original.

THE PEOPLE OF THE STATE OF NEW YORK, Complainants,
vs.
TATE OF NEW JERSEY and PASSAIC VALLEY SEWERAGE COMMIS-
SIONERS.

On consideration of the motion to extend the time for tak-
59 ing testimony in this case,
It is now here ordered by the Court that the time for
mplainants to take further testimony be extended to the first

day of October, 1912, that the defendants may take testimony between the second day of October, 1912, and the first day of February, 1913, and that the complainants shall then conclude the taking of further testimony on or before April 30th, 1913.

April 15, 1912.

KENNETH ALLEN, a witness called on behalf of Complainants, recalled for further examination, testified as follows:

Direct examination by Mr. O'Sullivan (continued):

Q. Mr. Allen, did you conduct any experiments or observations relative to the current velocities of the waters in the vicinage of Robbins Reef?

A. I did.

Q. And did you note the result of those observations?

A. Yes.

Q. Have you got a copy of them with you?

A. I have.

Q. Will you let me have it, please?

(Witness hands copy to Mr. O'Sullivan.)

Q. Just describe what observations were made, giving the time when they were made and the depths of water in which they were made and how you determined the locations?

A. We took the boat "Hattie Bell" and went to the location as near as we could determine by the eye, of the proposed outlet of the Passaic Valley sewer. The depth was found by sounding, and then the velocity was determined in this way: We took one of the small double can floats which we had used in the float observations, and then tied a cord to that 100 feet long. This was placed over the side of the boat, and the time for its passage of 100 feet was noted with a stop watch. That gave the velocity of the current and of the float. This was done with different depths of the lower can, so as to observe the velocity of different strata of water, generally 5 feet, 20 feet and 40 feet from the surface. The times, depths and directions were noted. The directions were observed generally with an
1060 azimuth compass, sighting to the can at the end of the period, and these were checked by noting some prominent point in that direction, or some prominent object, such as the Statue of Liberty or the mouth of the East River. Those observations gave the direction and the velocity at 5, 20 and 40 feet depths.

Q. Did those observations cover the work of several days?

A. Yes.

Q. And did you cause the results of your observations to be tabulated?

A. I did.

Q. And you have them with you?

A. I have.

(Witness produces tabulation.)

Mr. O'Sullivan: I offer those in evidence and ask that they be marked Complainants' Exhibit No. 92.

Mr. McCarter: I object to them as irrelevant and incompetent.

The Commissioner: Note the objection.

Received and marked Complainants' Exhibit No. 92.

Marked Complainants' Exhibit No. 92.

Q. Are you the author of any books, Mr. Allen?

A. One book.

Q. And what is its title?

A. Sewage Sludge.

Q. Are you the author of any pamphlets?

A. I have written a number of papers before societies, which have been reprinted.

Q. Can you name some of them?

A. One was on The Use of the Salinometer in Studies of Sewage Disposal, one on the Sanitary Protection of Water Supplies, one on The Construction of a Wood Stave Conduit at Atlantic City, and one on The Pollution of Oysters by Bacteria. That was before the American Public Health Association, and the previous one was before the New England Water Works Association. Those are the only ones I happen to think of.

Q. And before whom was the one on The Salinometer—on your studies of sewage disposal?

A. That was read before the New England Water Works Association, and published by The Boston Society of Engineers.

Q. Mr. Allen, how long have you been with the Metropolitan Sewerage Commission?

A. About 4 years.

Q. Now, in addition to the work that you have described
1661 as a witness, have you done any other work of a remedial character for the conditions that you have testified to?

A. Well, I have made studies and general plans for the collection and disposal of sewage at different parts of the city.

Q. In relation to the sewage of what city?

A. New York City.

Q. To what extent, just describe in a general way to what extent you have gone into this study, and whether you made designs?

A. We have made preliminary designs. They are not worked out with very much detail, but that I have done this for Jamaica Bay District, about Jamaica Bay, and certain portions of Manhattan, and I have made some study of Long Island City and the upper part of Brooklyn.

Q. Under the guidance of the Metropolitan Sewerage Commission?

A. Yes.

Q. And for the purpose of remedying the conditions that you have noted here?

A. Yes.

Cross-examination by Mr. McCarter:

Q. The measurements of the currents indicated upon the exhibit that has been offered this morning were made by whom, in association with you?

A. These observations covered several days. I do not remember the number. It may have been seven or eight, and for several days at first, I made them personally. The others were made by Mr. John P. Fox, Dr. Parsons, David Morey, George H. Shaw.

Q. So far as the observations that were made in your personal presence are concerned, they involved the work of other people besides yourself?

A. I think I had an assistant with me, besides the crew on the boat.

Q. Was the character of the floats the same as you testified about the previous time?

A. Yes.

Q. With regard to the measurements of the observations that were made in your absence by these other people, you have accepted their report and incorporated that in this document?

A. Yes.

Q. I notice that one of the elements that enters into this document is the wind. I imagine the condition of the wind would be
1662 very material upon this question of the velocity of the current?

A. The influence of the wind would be in two ways. The wind would affect the current itself to a certain extent by friction on the surface of the water, and it would affect the motion of the float by action on the top of float. The construction of the float would have no influence on the first of these actions, and the action of the wind directly on the float was known not to be great, because the upper float projected very little above the surface, and the lower float, which was supposed to indicate the velocity at the point at which it was located, was much larger. The top float would have been influenced in a strong wind to a certain degree, but a very slight degree. That was ignored.

Q. What was ignored?

A. The influence of the wind on the float. The direct influence of the wind on the float. No correction was made for that, that is what I mean.

Q. How did you measure the distance 100 feet?

A. The cord that was attached to the top of float was 100 feet long to a certain knot or mark on the cord. The float was set out from the boat and after the cord was taut between the top and the bottom float, the time was noted, and the position. The observer stood opposite that point and waited until the cord was stretched out 100 feet.

Q. Who made the calculation converting the observed velocity into feet per second?

A. I think those were made by the observer.

Q. Is the condition of the tide noted?

A. The time after high water or low water, Governor's Island, is noted, so we always have a reference to that on each day. It is not noted otherwise, but it is given in every case. HWGI is the mark denoting high water at Governor's Island.

Mr. McCarter: I think that is all.
Mr. O'Sullivan: That is all, Mr. Allen.

PAYN B. PARSONS, a witness called on behalf of Complainants, recalled for further examination, testified as follows:

Direct examination (resumed) by Mr. O'Sullivan:

1663 Q. Doctor, I hand you Complainants' Exhibit No. 92, relating to observations of current velocities in the vicinage of Robbins Reef. Mr. Allen has just testified that you collaborated with him in some of the work. That is correct, is it?

A. Yes, that is correct.

Q. Doctor, did you perform any oxygen determinations during the year 1911?

A. Yes, I did.

Q. You have already testified, if I remember rightly, that you made many oxygen determinations during the year 1909?

A. Yes.

Q. And they have already been put in evidence through you?

A. Yes, sir.

Q. Now, confining your attention to the year 1911, how many samples did you analyze for dissolved oxygen, Doctor?

A. I analyzed during 1911, 2342 samples of water for dissolved oxygen.

Q. Who made the analyses?

A. I made them all.

Q. Personally?

A. Yes.

Q. Who collected the samples?

A. I collected my own samples.

Q. Now, Doctor, will you describe the method you employed in making the collection of the samples and in subjecting them to the analytical tests?

A. Samples were collected in a weighted collecting apparatus, made out of lead pipe, in order to allow it to be lowered to the proper level, without being affected by the tides or currents, and the collection was made in the separatory funnel enclosed in this collection apparatus, and tests were made on the boat directly in this separatory funnel, immediately after collection. The temperature of the water and the salinity were also recorded at the time of collection. In making the tests there were two collections. That is, duplicate samples taken at each point. In one there were placed 4 cubic centimeters of a 10 per cent. solution of sodium carbonate, and 6 cubic centimeters of standard ferrous sulphate solution. They were then shaken, or the separatory funnel was then shaken, and after about three minutes the sulphuric acid standard, which con-

sists of 50 per cent. solution was added, and the contents of the funnel were then titrated with standard potassium permanga-
1664 nate. To the other, in the other funnel, which was a duplicate sample 10 cubic centimeters of sulphuric acid was added first, then six cubic centimeters of the ferrous sulphate standard solution were added and this was titrated. The contents of this funnel was titrated with the same standard permanganate solution. Then the difference was obtained between the results from the two titrations. The amount in the separatory funnel, which has been first described was subtracted from the amount found in what I call the blank sample, described secondly, and the number of cubic centimeters per litre figured from this, each funnel being numbered and being accurately calibrated. The percentage of saturation was then obtained, after having obtained the number of cubic centimeters per litre and knowing the salinity and the temperature of the water, the percentage of saturation was obtained by reference to a diagram devised and contained in the Fifth Report of the Royal Commission of Great Britain—the Royal Commission on Sewage Disposal of Great Britain.

Q. How did you determine the salinity, Doctor, that you say you made a determination of, at the time of the collection of the sample?

A. The salinity was obtained by means of the special salinometer used by the Commission. It is a hydrometer with a thermometer attachment so that the specific gravity of the water is obtained by reading the marking of the salinometer and making the proper correction for the temperatures, the salinometer being graduated at 60 degrees.

Q. In each individual case did you record the salinity and the the samples?

A. Yes, in every case.

Q. And where were these analyses made?

A. They were made on the boat. We had the boat fitted up for what we called a floating laboratory, and did all the work on the boat.

Q. What parts of the Harbor did you cover in selecting your samples, in making these determinations?

A. Well, I covered the Harbor very th-roughly. Covered
1665 the Lower Bay very th-roughly, the Narrows, the Upper Bay, the Kill van Kull, Newark Bay, the East River below Hell Gate and between Hell Gate and Throgs Neck, considerable of Long Island Sound, the Hudson River as far as the City limit, and occasionally a little above it, Yonkers. That is to say covered practically all the Metropolitan District.

Q. You recorded the locations at which you collected the samples, those were all recorded?

A. Yes, they were recorded in note books.

Q. Did you make any cross section at any given points?

A. Yes, we made a great many cross sections.

Q. And these you have all recorded?

A. Yes.

Q. How did you express the results of these tests that you submitted the samples to?

A. The results are expressed in cubic centimeters per litre.

Q. That is volumetric?

A. Yes, and also in percentage of saturation.

Q. You expressed them in both methods?

A. Yes.

Q. How did you obtain the saturation figures, Doctor?

A. By comparison with a diagram which I have described as contained in the Fifth Report of the Royal Commission on Sewage Disposal of Great Britain.

Q. Have you got that blue print with you?

A. Yes, I have a blue print of that diagram.

Q. With which you have compared your work?

A. Yes.

Q Will you let me see it Doctor?

(Witness produces blue print.)

Q. Is this blue print which you have handed me, and which you have described as the diagram of the Royal Commission on Sewage Disposal, regarded by you as a standard?

A. Yes.

Q. Did you compare your work with that standard?

A. Yes.

Mr. O'Sullivan: I offer that blue print in evidence.

Mr. McCarter: Before you do that, I would like to examine him a little about it.

Mr. O'Sullivan: All right, sir.

1666 Cross-examination by Mr. McCarter:

Q. I ask for a little information, Doctor, concerning this blue print, about which Dr. O'Sullivan has just asked you. Where did this blue print come from?

A. Well, that blue print—I did not make that blue print myself. All I can say about the blue print as direct evidence, is that it was handed to me by the President of the Commission with instructions to use that in making up my percentages.

Q. Where he got it from or anything else about, you do not know personally?

A. I have seen the diagram in the Fifth Report, but I have not compared it exactly, so that I cannot say whether it is an exact copy or not.

Q. Assuming now that it is so, I am going to ask you to go over it with me and explain it. Now, on the assumption that it is both accurate and a proper standard, both of which you have assumed?

A. Yes.

Q. Then it was used by you in what way to enable you to obtain the information that you are after; I am simply asking for information.

A. It is like this, Mr. McCarter: there is 70 degrees, that is

Fahrenheit (indicating), and then I took the salinity of the water, that is to say the specific gravity, call it salinity. That is reduced to specific gravity. When I obtained the specific gravity I took a ruler, put it on 70, ran it until I came to the specific gravity, which is expressed on this line (indicating), the oxygen required to saturate the distilled water, or say, fresh water, absolutely fresh, without any salt. Coming down here where this line crosses (indicating) 70 is the saturation figure. Reading according to cubic centimeters per litre, according to the wording at the left of the diagram, where it says, "volume of oxygen at no degree centigrade, and 760 milometers barometic pressure," in cubic centimeters per litre of water.

Q. Now, let's see how we read that on the assumption of 70?

A. Follow 70 down to this line (indicating). Then read across—if I had another ruler I could cross this line here, this rather sharp line, 65, that crosses this line at 68. So the saturation figure 1667 for water at 68 degrees, and fresh water, would be, roughly, without using a ruler, 6.5 cubic centimeters per litre, and sea water is the lower line, that is 100 per cent. sea water.

Mr. McCarter: I object to the exhibit as irrelevant and incompetent.

The Commissioner: Note the objection. Received and marked Complainants' Exhibit No. 93.

Marked Complainants' Exhibit No. 93.

Direct examination by Mr. O'Sullivan (continuing):

Q. In regard to your answer that you collected all these samples yourself, I wish to ask you were you ever accompanied on any of these trips by other scientists?

A. I have done this work before a good many prominent men, more or less prominent men. Different chemists of various sorts. I have done the tests in the presence of Professor Gill, Professor of Chemistry at the Massachusetts Institute of Technology. I have done them in the presence of Professor Metzger, Professor of Chemistry at Columbia; I have done them in the presence of Mr. Fitzgerald, formerly President of the American Society of Civil Engineers; I have done them in the presence of Mr. Harrison P. Eddy, Consulting Engineer at Boston; I have done them in the presence of William P. Copeland, who has charge of the Columbus Water Purification Works. That is all that I recall at the present time. I have also done them in the presence of the Metropolitan Sewerage Commissioners.

Q. You mentioned Professor Metzger. Did he at any time make a check of the experiment to verify your findings?

A. Professor Metzger has worked along with me through the whole thing. He made all the standard solutions that I used. Being on the boat, I had no time to make up my own standards, and throughout the whole year, he made up the standard solution to use, and several times he took trips with me on the boat and did tests along with me to see how the method ran.

Q. You have described the method you employed as to the solutions used. Is there any special name for that process itself?

1668 A. I prefer not to give the method a definite title. I cannot say what title Dr. Soper, in the report he is getting out, is going to give to it. It is a modification of the method used by the Royal Commission on Sewage Disposal of Great Britain.

Q. Doctor, at the time that you collected the samples and made these oxygen determinations, employing the methods that you have described, did you record those individual determinations in field note books at that time?

A. Yes.

Q. And have you produced them here now in court?

A. Yes, I have all the note books here.

Q. All right, I just wanted to bring out the fact that you have them here.

(Witness produces note books.)

A. I have them all here.

Q. Now, Doctor, taking this long range of work, covering, as you say, the year 1911, were these separate determinations tabulated; have you arranged them in tabular form?

A. Yes, they have been arranged in this tabular form as shown here. In the form of averages also.

Q. I want to first get the tabular form. Let me see it, sir.

(Witness produces tabulation.)

Q. Have you arranged those separate determinations, giving the numbers of the samples, the hours at which the samples were taken, the approximate locations at which the samples were taken, the exact locations given in latitude and longitude, the number of feet below the surface at which the sample was secured, the condition of the tidal current at the time the sample was secured, the temperature of the water the percentage of land water in the sample and then showing the oxygen contents, both by the volumetric method, cubic centimeters per litre, and the other method, showing the percentage of saturation. Have you the tables now showing these arrangements for the year 1911?

A. Yes, I have.

1669 Q. Will you produce them?

A. Yes.

(Witness produces tables.)

Mr. O'Sullivan: I offer in evidence tables showing the long series of oxygen determinations made by this witness as testified to by him now. I offer them in evidence and ask that they be marked Complainants' Exhibit No. 94.

Mr. McCarter: I will have to object to them in the first place because they cover territory that seems to us entirely irrelevant to this controversy, and are therefore irrelevant and immaterial, and secondly because they are not accurately proven.

The Commissioner: Note the objection. Received and marked Complainants' Exhibit No. 94.

Marked Complainants' Exhibit No. 94.

Q. The tables of dissolved oxygen determination, which you handed me, Doctor, and which are now marked as Complainants' Exhibit No. 94, they show the different areas, *the different areas*, the different times and the different conditions under which these determinations were made. Have you also arranged the oxygen determinations made by you in a table of averages for these locations?

A. Well, I would like to ask Doctor, just what you refer to?

Q. 1911?

A. I have here the averages for 1911, but I did not do the work personally.

Q. Did you compare the work of averaging the tabulations with the original work done by you?

A. Of course, comparing every single average, Doctor, would mean doing the work yourself. On the question of averages, it is a question of the man that does the work, he is the man that compares every thing, and if I had gotten to work and compared every single figure, I would have done the work. In 1909, I did the whole thing. I have the averages for 1909, which I made personally, as I did them, but 1911, that work was done by Mr. Holden, as Engineer in the office, as the exhibit is marked.

1670 Q. Is Mr. Holden with the Commission now?

A. Yes.

Q. Doctor, what work did you do relative to bacteria in 1909 on these water samples?

A. I collected a large number of samples of water and plated them out on the boat in standard gelatine and counted the plates after incubation, after 48 hours at 20 degrees centigrade, for the total numbers of bacteria.

Q. How many samples were analyzed for these bacterial counts during the year 1909, Doctor?

A. 1,162.

Q. Who made the analyses?

A. I made nearly all of them.

Q. Who analyzed the remainder?

A. Mr. Morey analyzed the rest under my supervision. He went out with me and helped me collect and plate the samples.

Q. Who collected the samples?

A. Where I did the work, wherever I did the work myself, I collected the samples, nearly all of them. Wherever Mr. Mory plated them out, he collected his samples. I was with him at the time. We worked together.

Q. Doctor, will you describe the method you employed in making the collection of the samples and in submitting them to analysis?

A. The samples of water were collected in glass vacuum tubes,

which are similar to a small glass test tube with an open end drawn out and sealed. It being a partial vacuum when the glass tip is broken the water rushes in and fills the vacuum tube. These glass vacuum tubes were lowered to the proper depth in a lead container, and when that container reached the proper depth the glass tips were broken off by means of a sudden jerk on a string attached to the sample. This sudden jerk broke the glass necks, and the water rushed in and being full, no more was taken in in the course of raising the sample to the surface. The samples were then plated directly out of these vacuum tubes into Petrie dishes, the proper dilution being used and gelatine being poured on the plates, which were then placed on the shelves of a refrigerator until shore was reached. As soon as shore was reached, the plates were placed in the 20 degree incubator, and allowed to incubate for 48 hours when they were counted.

1671

Q. And then what?

A. They were then counted. The total numbers of the bacteria. That is what we call counting the plates. The total number of colonies on each Petrie dish or plate. The word "plate" means a Petrie dish, "plate" simply being the common term, another name for a Petrie dish, which is the strictly scientific name.

Q. Where were these analyses made?

A. The analyses up to the point of the count were made on the boat. The plating was all done on the boat, immediately after collection. They were taken into the laboratory and at the end of 48 hours the counting was done.

Q. Now, as to the area over which you secured these samples. Did it occupy any considerable area of the Harbor?

A. The area covered was practically identical with that just described for oxygen in 1911. It covered practically all the region around New York including Newark Bay.

Q. Did you make entries in the field note books and laboratory note books on the occasion of securing each sample and making the analysis?

A. Yes, I did.

Q. How did you express these results later?

A. The results were expressed in the sample number, the location of the sample, the depth of the sample, the condition of the tidal current, the temperature of the water and the total numbers of bacteria per cubic centimeter. A record was also made of the stage of high water at Governors Island and the condition of the wind, the direction and velocity of the wind.

Q. Did you arrange these results that you have described Doctor, in tabular form?

A. Yes.

Q. Have you got those so arranged, have you those tables here with you?

A. Yes, I have.

Q. Will you produce them please?

(Witness produces tables.)

Q. Are these tables arranged according to the location in which the samples were obtained, the sample numbers being
1672 given, the hour at which the sample was secured, the approximate location from which the sample was taken, the number of feet below the surface of the water where the sample was taken and the tidal conditions, with the temperature, the percentage of land water, and then finally showing the bacterial count for each particular sample?

A. Yes, of course the arrangement is serial, according to sample number. The numbers proceed from 1 on through. There is no arrangement according to location. That is, simply the numbers, the collection and location, that is given opposite a serial number.

Mr. O'Sullivan: I offer these tabulations with the number of bacteria found in 1162 samples of water collected during the year 1909, which this witness has produced and testified to; I offer them in evidence and ask that they be marked Complainants' Exhibit No. 95.

Mr. McCarter: We object to these for the same reasons that were given to the admission in evidence of the last previous exhibit.

The Commissioner: Note the objection. Received and marked Complainants' Exhibit No. 95.

Marked Complainants' Exhibit No. 95.

Q. Doctor, in relation to the work which you have just been testifying to, and which appears in tabular form in Complainants' Exhibit No. 95, I ask you did you yourself make the analyses as therein set forth and reduced to tabular form and averages?

A. I did, for 1909, the bacteria for 1909.

Q. Have you got them with you?

A. I have, yes.

(Witness produces tables.)

Q. Do these tables of averages deal entirely with the samples analyzed and set forth in Complainants' Exhibit No. 95?

A. Yes.

Q. And was all the work in this table of averaging done by yourself?

A. Yes, I made up the averages myself.

Mr. O'Sullivan: I offer this table of averages for the year 1909, being a summary of tables included in the preceding exhibit, in dealing with the bacterial count, as testified to by this wit-
1673 ness, I offer that in evidence and I ask that it be marked Complainants' Exhibit No. 96.

Mr. McCarter: I object to it as incompetent, irrelevant and immaterial.

The Commissioner: Note the objection. Received and marked Complainants' Exhibit No. 96.

Marked Complainants' Exhibit No. 96.

Q. When you were on the stand previously, Dr. Parsons, you testified to the oxygen determinations made by you in the year

1909, and also oxygen tabulations were placed in evidence and marked Complainants' Exhibit No. 31. Did you reduce this voluminous set of oxygen determinations as they appear in that exhibit, on the table, to averages?

A. I did.

Q. Have you got that table of averages for the oxygen determinations of 1909 with you?

A. I have.

Q. Will you produce it please. (Witness produces table.)

Mr. O'Sullivan: I now offer in evidence table showing the average amount of dissolved oxygen in the waters of New York Harbor for the year 1909. I offer that in evidence and ask that it be marked Complainants' Exhibit No. 97.

Mr. McCarter: I object to it as irrelevant and immaterial and incompetent.

The Commissioner: Note the objection. Received and marked Complainants' Exhibit No. 97.

Marked Complainants' Exhibit No. 97.

Q. Now, Doctor, you have testified to the samples of water which you yourself obtained and which you made determinations of as to both oxygen and bacteria. Did you do any work relative to the deposits on the harbor bottom?

A. Yes. I collected some of the samples and determined the total number of bacteria in the samples of deposits in some of the samples.

Q. How many samples were analyzed microscopically?

A. About 1100, 1090 to be exact.

1674 Q. How many of these samples were also tested for the total numbers of bacteria?

A. About 400. of these samples of mud were also tested for the total numbers of bacteria. The whole number that I gave, 1090 were tested microscopically for the deposits in the bottom, for the material that could be discovered by microscopic tests and of those 1090 400 samples were tested for the total numbers of bacteria.

Q. 400 did you say, or 419?

A. It was about 400, the number.

Q. Who analyzed the samples microscopically?

A. The microscopical examinations were made by Dr. Raymond H. Pond and by Robert N. Hoyt.

Q. Is Dr. Pond now alive?

A. Dr. Pond is dead.

Q. Who did the bacterial work?

A. The bacterial work was done principally by me, and partly by Mr. Morey.

Q. Under your direction?

A. Yes.

Q. Who collected these mud samples *for* deposits on the harbor bottom samples?

A. They were collected partly by me and partly by Dr. Pond and partly by Mr. Hoyt.

Q. Describe the methods employed in making the collection of the mud samples, or samples from the deposits on the harbor bottom.

A. The surface samples were collected by me by means of a dredge, resembling more a mushroom anchor than anything that is generally known. It is a dredge made to order of a conical shape, so that the moving it along the harbor bottom would scrape off the top layer of the harbor bottom and retain a piece of the mud or sludge, whichever you prefer to call it, the deposits, retain it until it was drawn to the surface. The outer layer of this mud was removed by means of a flamed knife, a knife that had been sterilized by flaming. Then that was thrown away, the part that was removed. Below that, for microscopical analysis, a flamed spoon was used, and the samples placed in Mason jars and sealed and numbered. For bacteriological analyses a copper plunger was used and a small cylindrical sample of the sludge, weighing approximately a gram, was collected in this plunger and removed without handling to a sterilized test tube. These were num-
1675 bered to correspond with the samples of mud for microscopical analyses. The samples were then taken into the laboratory and tested in these two ways. The larger sample for microscopical deposits, and the small sample for the total number of bacteria.

Q. Where were these observations made?

A. The area covered was—well, practically similar to that as described under dissolved oxygen for 1911. It covered the Metropolitan area pretty thoroughly. Wherever samples could be collected, they were collected. That is to say in this general way. Wherever it was impossible to collect a sample, there was of course no analysis made, although the entire area was covered.

Q. Where were the analyses themselves made, Doctor?

A. The analyses were made in the laboratory of the commission at Pier A.

Q. How were the results expressed of these analyses?

A. Well, in addition to the data, the collection data which includes the location and the date and the number and the depth—in addition to those collection data, the color and odor of the sample are given, which were obtained on the boat at the time of collection.

Also the consistency as to whether it was soft or hard. Then in the laboratory the microscopical tests were made and in the tabular sheet submitted, the opinion was given as to whether the sample was polluted or not. In the cases of these 400 samples, in addition to the previous data, the total numbers of bacteria in each sample are given.

Q. As you collected these samples, as these various samples that you have testified to were analyzed, were records made at the time in both field and laboratory note books?

A. Yes.

Q. Were those arranged in tabular form subsequently?

A. Yes, sir, they were arranged in tabular form.

Q. Have you got the table showing the work done on the deposits of the harbor bottom in this tabular form now with you?

A. Yes, sir, I have.

Q. Will you produce them, sir?

(Witness produces tabular form.)

1676 Q. Do I understand you, sir, that these examinations of deposits from the harbor bottom not only show the location where the samples were secured, but the date of collection, the locations given approximately and exactly, both in latitude and longitude, the depth below the surface at which the samples were secured, showing also the color and odor and consistency, and the opinion of the examiner?

A. Yes.

Q. And you have now produced these in tabular form?

A. Yes.

Mr. O'Sullivan: I offer these in evidence and ask that they be marked Complainants' Exhibit No. 98.

Mr. McCarter: I object to that not only for the reasons given to the admission in evidence of the two last previous exhibits, but also on the further ground that it seems to include work done by Dr. Pond and Mr. Hoyt, and therefore includes not only data but opinion by gentlemen who are not produced and one of whom cannot be produced. Furthermore we think that insofar as the memorandum purports to give opinions of anybody it is improper. The data alone should be given and the report should exclude an opinion based upon the data.

Mr. O'Sullivan: I would like to say in reply to defendants' counsel that I will produce the gentlemen who really made the microscopical examinations this afternoon. Men who worked in collaboration with Dr. Pond, who is dead.

The Commissioner: Note the objection. Received and marked Complainants' Exhibit No. 98.

Marked Complainants' Exhibit No. 98.

Q. Doctor, directing your attention to Complainants' Exhibit No. 96, which contains a table of the averages for bacteria in the water in the year 1909, I would like to ask you how were these averages compiled, and by whom?

A. The averages were compiled by me personally, and in addition to the summary or the table giving the averages for all depths and tides, I have given the averages for surface and bottom samples of each, each section of the Harbor and also the averages for 1677 the two tides, ebb and flood, and in order to make the averages of more account, I have stated in the following pages exactly what samples were used in making up the averages, and I will add that in making up the averages all the samples collected in the various regions were used with the exception that in Gravesend Bay, where a special study was made of the Coney Island Disposal Outlet, the majority of samples being taken near the mouth of the creek, those samples were not included in the averages of Gravesend Bay, as it would have given a false figure for the Bay.

That also holds true for Jamaica Bay, where we made a special study of the larger disposal plant outlet at New Lots particularly. Where a large number of samples were collected near the sewer outlet, it would give a wrong impression of the large body of water in Jamaica Bay. With those exceptions the samples in the various sections were all averaged in, in order to avoid any difficulty.

Cross-examination by Mr. McCarter:

Q. I notice on these exhibits that you have given the longitude and the latitude. How did you ascertain that?

A. The latitude and longitude is not my work. It was done by the draftsman in the office. The location was obtained by me and given in the field book and the thing was plotted. It was for the sake of convenience in plotting, rather than for scientific use. The latitude and longitude was figured on the standard chart, so that in transferring from one chart to another, the latitude and longitude could be read on the side of the chart and the exact point on the chart marked there. The observations of latitude and longitude were not observed by me, but were plotted in the office.

Q. Now, for instance, I just happen to observe on Exhibit No. 96, that on the first page, sample No. 3 is said to be farther east than sample No. 1?

A. Yes.

Q. And sample No. 1 is about 2000 feet from Constable Hook, and samples 4, 5 and 6 are the same as sample No. 3, namely, each of them is indicated as farther east than sample 1 or sample 3?

A. The point of that is, the readings on those samples
1678 were taken by means of the sextant. At a point like the Upper Bay, where it is rather difficult to judge the exact distance from shore, we took readings by a sextant, readings by a point such as the large chimney at Constable Hook, or the Statue of Liberty, or Black Tom Island, and on the two chimneys of the Edison Company in Brooklyn, and on the Crescent Athletic Club and obtained three angles which were sent to the draftsmen, and I expressed it—instead of putting the exact sextant readings on the tabular sheets I put the sextant readings in front of the draftsman to show him where the samples were. I expressed it as further east than Sample No. 1. That is simply a rough way of putting it, while the exact location was given by the sextant. It would not mean anything to anybody else reading over the report.

Q. As a matter of fact the draftsman had before him when he prepared the tracings from which blue prints were taken, the exact location of sample No. 3?

A. He had the sextant reading yes.

Q. The bacterial examinations simply resulted in ascertainment of the number of bacteria?

A. That is all.

Q. Whether or not they were nocuous or innocuous it does not show?

A. No.

Q. Therefore, with the exception of the mere number, it is of no particular moment here?

A. Simply shows the total numbers.

Q. There are of course a great many innocuous bacteria, are there not?

A. Yes, a great many.

Q. And the ascertainment of the quantity of bacteria in a given instance, for instance, sample No. 6, 12,700 in a cubic centimeter, is by actual count?

A. Dilutions are made. Now, for instance, supposing I have a water that has 1000 bacteria in it. It would be difficult to count 1,000 in a little dish, so I take that water after I collect it, I take one cubic centimeter of that, and put it in 9 cubic centimeters of distilled sterilized water. Now, when that is shaken up it makes a dilution of 1 to 10. So your Petrie dish contains 100 bacteria, and multiply that by 10, which gives you the total number, having made a dilution of 10.

1679 Q. In that way it is possible to do it?

A. That is the only way possible to be accurate.

Q. Did the microscopic examination of the specimens taken from the harbor bottom tend to display the chemical constituents of the specimens?

A. They looked for what the analyst, after advisement with the Commissioners, considered polluting material, such as glumes, seeds of various sorts, hair, material like that.

Q. Then the design of the microscopic examination was to ascertain whether or not the given specimens contained the materials that you have described, which by the assumption were considered polluted?

A. Yes.

Mr. McCarter: That is all.

At 1 P. M. an adjournment for noon recess was taken until 2 P. M.

CORPORATION COUNSEL'S OFFICE,
NEW YORK CITY, 2 P. M.

CHARLES A. HOLDEN, a witness called on behalf of Complainants, being first duly sworn, testified as follows:

Direct examination by Mr. O'Sullivan:

Q. Your full name?

A. Charles A. Holden.

Q. Where do you reside?

A. Mt. Vernon, New York.

Q. Are you connected in any official capacity with any of the commissions in this City?

A. Yes, sir.

Q. Which one?

A. The Metropolitan Sewerage Commission of New York.

Q. In what capacity?

A. As Assistant Sanitary Engineer.

Q. In the course of your line of duties, Mr. Holden, were you at any time called upon to make averages of the oxygen determinations made during the year 1911?

A. Yes, sir.

Q. I show you a document and ask you if you recognize it as your work?

A. Yes, sir.

1680 Q. What is that?

A. It is a table showing the averages of amounts of dissolved oxygen in the water at 10 locations in New York Harbor.

Q. That is the first page?

A. Yes, sir.

Q. Where did you get the data to make these tables of averages?

A. From the original reports as submitted by Dr. Parsons who made the analyses.

Q. The reports were made to whom?

A. The reports are not addressed to any person, but they are handed in to the president of the Commission, Dr. Soper.

Q. You mean the Metropolitan Sewerage Commission?

A. Yes, sir.

Q. Did you use these tables that I now show you that are marked as Complainants' Exhibit No. 94?

A. No, sir.

Q. What relationship have these two sets of tables, the ones that you say you prepared and the ones I show you as Complainants' Exhibit No. 94?

A. The data contained in both sets of tables are derived from the same source.

Q. What source is that?

A. The original report as submitted by the analyst.

Q. What did you do with the original figures that you got from the original reports; how did you handle them in making your tables of averages?

A. I took all the figures taken on a certain day at a certain location in the Harbor and averaged them first by depth, that is, all the figures taken at 1 foot depth, at a certain location on a certain day were added up and averaged. The same was done for the results of analyses taken of samples taken at mid depth, and at the bottom, the same location. That is they were averaged that way for flood current observations. The same was done then for ebb observations, and then the averages of the two currents were gotten.

Q. And do all these averages that you have just described, both for ebb and for flood, for various depths and for both ebb and flood, do they appear in the set of tables that you hold in your hand?

A. Yes, sir.

Q. And they were prepared by whom?

A. By myself.

1681 Q. Personally?

A. Yes, sir.

Q. And from the sources that you have just described?

A. Yes, sir.

Mr. O'Sullivan: I offer this table of averages, showing the averages for dissolved oxygen determinations made during the year 1911, which has been described by the previous witness, I offer those in evidence and ask that they be marked Complainants' Exhibit No. 99.

Mr. McCarter: I object to it as incompetent, irrelevant and immaterial.

The Commissioner: Note the objection. Received and marked Complainants' Exhibit No. 99.

Marked Complainants' Exhibit No. 99.

Q. Are you still with the Metropolitan Sewerage Commission, Mr. Holden?

A. Yes, sir.

Q. And your more recent work embraces what character of work, remedial or investigation?

A. Why, mostly in the design of sewerage projects.

Q. You are now engaged on them?

A. At the present moment, I am engaged in helping in the preparation of the forthcoming report of the commission.

Cross-examination by Mr. McCarter:

Q. Mr. Holden, a little bit more information please, with regard to the ascertainment of averages. If I understand your testimony correctly you had a bottom and a middle depth and some depths of samples?

A. Yes, sir, and a sample was also taken near the surface.

Q. And in order to ascertain what you call the average, you took all of the bottom, at a given tide, at a given day?

A. Yes, sir.

Q. And averaged them?

A. Yes.

Q. Is that given here as an average?

A. Not in the summary, but in the body of the table.

Q. The first page or two are summaries?

A. The first page is a summary of all the rest of the table.

Q. And the average with regard to what you call the middle depth and the bottom, the same way. You took the average of the bottom at a given location for a given day or tide?

1682 A. Yes.

Q. What would be the basis of your averaging?

A. It was divided off primarily into currents. That is, all the samples taken on a certain current, at a certain location on a certain day were averaged, by first setting down those that were taken at a depth of 1 foot adding them up and averaging them. Then taking those at mid stream depth, those samples, and averaging them. Then the bottom samples and averaging them, and then having those three results, adding them up and averaging them would give the average for all depths on the particular current under consideration. The same was done for the other current. That gave two averages, one for each current for all depths. Those two averages

were averaged to give an average for both currents, at all depths, for that particular day. The summary does not contain the averages at different depths, but it does contain the averages for both currents, for the ebb current and for the flood current, for each day, on which samples were taken at each of the ten locations shown. Also it shows the averages of those averages for each of the locations for all of the days on which samples were taken at those locations.

Mr. McCarter: That is all.

Redirect examination by Mr. O'Sullivan:

Q. You used the word "current." Will you explain what you mean by that word?

A. The ebb current is the flow of the water in the river or channel toward the ocean. The flood current is the flow of the water away from the ocean towards the land.

Q. And when you used the term in the plural "currents" you meant us to understand the ebb and the flood?

A. Yes, sir.

ROBERT N. HOYT a witness called on behalf of Complainants, being first duly sworn, testified as follows:

1683 Direct examination by Mr. O'Sullivan:

Q. Where do you reside, Mr. Hoyt?

A. I reside at Princeton, New Jersey.

Q. Do you hold any position over there, any public position?

A. I am Health Officer of the Borough of Princeton.

Q. Where did you study and where did you graduate from?

A. I studied at the Massachusetts Institute of Technology in Boston and was graduated with the degree of Bachelor of Science in June 1909 from the Department of Biology.

Q. Have you made a specialty of any line of work during that time?

A. I made a specialty of sanitary biology.

Q. Just describe what you mean by sanitary biology?

A. By sanitary biology I mean bacteriology, especially the study of pathogenic bacteria and microscopy as applied to public health work, and of chemistry as applied to public health work.

Q. Were you ever a member of the staff of the Metropolitan Sewerage Commission of this State and City?

A. I was employed by the Metropolitan Sewerage Commission as microscopist for six months, from about July 15th, 1909, to January 15th, 1910.

Q. What line of work did you take up after January 1910?

A. I was employed by the City of Summit, New Jersey.

Q. What State?

A. Summit, New Jersey, as a bacteriologist and health inspector from March 1st, 1910, to September 15th, 1911.

Q. What was the character of the work that you did in Summit, New Jersey, for the Board of Health?

A. Made microscopic examinations of the water supplies. I made bacteriological examinations of the water and milk and of specimens submitted by physicians for diagnosis. I made chemical examinations of the milk. I inspected the dairies and made general sanitary inspections.

Q. In your present line of work, does not this same line of work prevail at Princeton?

A. My present line of work in Princeton is along this same line. It is extended to some extent.

Q. You now hold that position in Princeton, New Jersey?

1684 A. I now do hold that position.

Q. During your connection with the Metropolitan Sewerage Commission, what work did you do for them; just describe the general nature of the work in the laboratory and collecting samples.

A. The bulk of my work was performed in the laboratory. It was a microscopic examination of samples of mud at the surface of the harbor, the bottom of New York Harbor and adjacent waters. I was also employed to make a certain number of current determinations near Robbins Reef Lighthouse in New York Harbor, and I also collected a certain number of these mud samples.

Q. I show you complainants' Exhibit No. 92, current observations near Robbins Reef, and ask if you aided in doing that work?

A. I aided in work of this nature.

Q. What was the purpose of your microscopic examination of these harbor deposits?

A. The purpose of these microscopic examinations of those samples of mud was to locate the areas in New York Harbor and the adjacent water, where there are deposits of solid matter from sewage that runs into the harbor.

Q. Now, will you describe the method you employed, stating how you made your collection, your examination and what interpretation you made of the analyses of observations?

A. I will read from my report which I made at the time. I was microscopist to the Metropolitan Sewerage Commission. The procedure consist of two parts: First, observations were made of the color, odor and composition of the sample when collected, and, second, a search was made for macroscopic particles which had probably come from sewage. When Dr. Pond had examined about 600 samples of mud, I took up the work.

Collection.

The mud samples from the surface were collected by means of a small iron dredge shaped like a mushroom. The dredge consisted of a rod two feet, three inches long set firmly in the apex of a sheet

1685 iron cone, six inches deep and twelve inches across the base. This mushroom dredge was dragged over the surface of the mud until the cone was partly filled. It was then raised and a pint sample was spooned out into a pint glass fruit jar. Before washing the remaining mud out of the dredge, notes of the color, odor and composition of the dredging were made.

Examination.

The examination of mud samples in the laboratory was carried on as follows:

First, the macroscopic particles or debris were washed free from mud, and, second, the debris was placed in a large Petrie dish over a white porcelain slab, and third, the particles which seemed likely to prove of interest were picked out and identified.

In polluted samples, the debris was generally blackened with ferrous sulphide so that it was necessary to decolorize them in ten per cent hydrochloric acid. Mounts for microscopic examination were made in glycerine. To wash the debris free from mud, Dr. Pond filled the glass jar containing the mud with water, stirred with a glass rod, and poured the suspended mud out onto a perforated porcelain plate fitting snugly in an agate fruit jar funnel. The mud was washed out through the perforations and the clean debris was washed off of the plate into a small glass pitcher. This process was repeated until the required amount of debris had been obtained. He then proceeded to examine the debris and write out his report before beginning a second analysis. The porcelain plate used was two and three quarters inches in diameter and the perforations were between one twentieth and one fortieth of an inch in diameter. Personally I have been able to make faster progress by washing out 10 to 15 samples in succession and then setting aside the washing apparatus and devoting myself to examining the debris. I have also changed the method of washing out the debris to some extent. First, I washed the entire contents of the jar out onto a copper sieve with meshes one twentieth of an inch apart. All but the coarsest particles of the sand passed through. Then the sieve was inverted over the fruit jar funnel and the debris washed into a large glass pitcher. By agitating the pitcher and pouring out quickly onto the porcelain plate the valuable debris was obtained free from mud. By this method a sample could be made ready for examination in less than eight minutes on the average.

1686

Identification of debris required less and less use of the microscope as the macroscopic appearance of particles of diagnostic value became more and more familiar, but in practically every case a diagnosis of pollution was supplemented, backed up by a microscopic examination of animal hairs, bits of paper and so forth. The microscope used was a "Spencer" with a one and one quarter eye piece and three objectives of one sixth, one third and two thirds inch focal length, giving magnifying powers of 530, 250 and 118 diameters respectively.

A dozen permanent mounts of the debris from various parts of the harbor have been made for study and comparison has also been made of a collection of vegetable and animal fibre debris from fresh feces, fresh manure and the city sewage.

I will say the presence in a sample of mud of bits of hair glumes of oats, bits of newspaper, fruit skins and other debris commonly found in sewage was taken to indicate pollution and that freedom from such debris was taken to indicate freedom from pollution.

Q. And the optical search that you made for sewage solids how is that done?

A. The optical search for sewage solids is direct and simple and requires very little apparatus. 23 samples have been examined carefully in one day by this method. Animal hairs, glumes and bits of newspaper find their way into the harbor in some way besides through the sewers. Small amounts of street sweepings, probably are blown from the city barges whcih transport them to Rikers Island and newspapers are thrown into the harbor from boats and piers, but in neither case would foul deposits be formed which would be likely to deceive the analyst. The principal source of the oat glumes is the horse droppings washed into the sewers by the rain and street washings. Animal hairs of various kinds
1687 are washed into the sewers from the streets and human hair from bath tubs and washbowls. Newspaper is generally used by the poor in place of toilet paper. Observations of the color, odor and composition of the mud when collected would be sufficient to distinguish the very clean from the heavily polluted samples but foul odors and black color may be caused by decomposing peat, clams and sea weed.

Q. What were the results of these examinations which you conducted as you have described?

A. The examinations made by Dr. Pond and myself show that a large part of the bottom of New York harbor is polluted with deposits of solid matter from sewage. The bottom of the Upper Bay is generally polluted except on the Jersey flats west of a line from Constable Hook to Black Tom Island. The bottom near the shores of Manhattan Island, near the Jersey shore opposite Manhattan and the Long Island shores of the East River are polluted almost everywhere out at least to the pier head line. Midstream in the Hudson and East Rivers, the bottom is fairly free from deposits of sewage solids and is generally so hard that samples can be obtained only with difficulty. The lower Bay is polluted along the principal ship channels. Frequent foul deposits were found in the Kill van Kull and Newark Bay, especially near Elizabethport and Newark. The deepest deposits were found at the pier head line off Elizabethport, Port Richmond, Hoboken, and at the mouth of the Gowanus Canal.

Q. Doctor, I show you Complainants' Exhibit marked No. 98, being the examination of the deposits from the harbor bottom, and ask if any part of your work appears in that exhibit?

A. The column headed "Opinion" is the work of myself and Dr. Pond. In the first 600 samples it was the work of Dr. Pond, in the samples from 600 on, it was my own work.

Q. 600 on to what number?

A. To 1100.

Q. Was your own individual work?

A. Was my own individual work.

Q. And the other work was in conjunction with Dr. Pond?

A. The other work was either done by Dr. Pond or by Dr.
1688 Pond and myself in conjunction.

Q. I do not recall if you described how these samples were collected; that is, the surface samples and the deep samples?

A. The surface samples were collected by means of a dredge of mushroom shape which was dragged along the bottom of the harbor until it had scraped up some mud into the mushroom, into the dredge. The dredge was then hauled up and a sample spooned out. The deep samples were obtained by mud borer. It was an iron pipe of about 3 inches diameter, which had been cut in a longitudinal. It had a handle affixed to one end. This pipe was pressed down into the surface of the bottom of the harbor as far as possible. It was then pulled up and samples spooned out at various depths from the core of mud which was obtained. Before the samples were spooned out, however, the surface was carefully scraped off so as to avoid contaminating the portions of mud which came from below the surface, with mud from the surface as it was pulled up.

Q. How deep were the deepest borings?

A. I believe that in one or two cases the borings were 12 feet in depth. I could tell by referring to my reports. I know that they went to a depth of 10 feet in more than 1 instance.

Q. I see you have some samples there with you, Doctor, what do those show?

A. These samples which I hold in my hand show the location of certain samples, and by the mark—nature of the mark, they show the opinion which was reached after examining the mud from these locations.

Q. Take the first one; can you just describe the first one?

A. The first sample, the sample which I now hold in my hand, is of the Upper Bay of the Hudson River and of the East River, Kill van Kull and Newark Bay. Also a small portion of the Lower Bay. The location of the sample is shown by a circle. In those cases where the sample was judged to be polluted, the circle is filed in solid white. Where the sample was judged to be unpolluted, the circle is not filled in at all. Where the sample was doubtful,
1689 when the analyst was in doubt as to whether the sample was polluted or not, the circle is half filled in with white.

Mr. O'Sullivan: I offer the plottings of this witness' microscopical examinations showing the locations at which the samples were obtained, and the coloration as the witness has testified to, indicating the opinion formed from the examination of the sample, I offer this chart in evidence and ask that it be marked Complainants' Exhibit No. 100.

Cross-examination by Mr. McCarter:

Q. Mr. Hoyt, I suppose that some of the indications by circles upon the map, about which you have just been testifying are of samples taken by Dr. Pond?

A. Some of them are.

Q. You are unable, I suppose, to differentiate on this map, the work that is your own work and that which is Dr. Pond's?

A. I am able to differentiate, because—that is, where the numbers are legible. Each circle, if you will notice, has a number below it, which is the number of the sample. Where those numbers are

over 600, they are my work. Where they are the lower numbers, the work was done by Dr. Pond or Dr. Pond and myself in conjunction.

Q. How were those circles plotted on the map?

A. They were plotted on the map by a Mr. Berrey, I believe, who arrived at the location of the samples from sextant readings which were given to him by the person who made the collection of the samples.

Mr. McCarter: I object to the exhibit as incompetent, irrelevant and immaterial.

The Commissioner: Note the objection.

Received and marked Complainants' Exhibit No. 100.

Marked Complainants' Exhibit No. 100.

Direct examination by Mr. O'Sullivan (continued):

Q. What does the second chart or map show?

A. The second chart or map, which I hold in my hand, shows the location of surface samples in the Lower Bay, Raritan Bay and Arthur Kill. The same signs are used as described in the former map to indicate whether the sample was judged to be polluted—unpolluted, or whether the pollution was doubtful.

Mr. O'Sullivan: I offer in evidence the chart or map showing the locations of the samples, as to oxygen and the opinion
1690 of this witness on the microscopical examination of such samples as are plotted on this chart or map, and I ask that it be marked Complainants' Exhibit No. 101.

Cross-examination by Mr. McCarter:

Q. Is the same thing true of this map as appears concerning the previous one, that some of it represents work done by yourself and some represents work done by Dr. Pond and some by both of you jointly?

A. It does.

Q. And if the numbers are visible, the same thing would be true of them, that they can be identified by reference to the other points?

A. That is true.

Mr. McCarter: I object to it as incompetent, irrelevant and immaterial.

The Commissioner: Note the objection. Received and marked Complainants' Exhibit No. 101.

Marked Complainants' Exhibit No. 101.

Direct examination by Mr. O'Sullivan (continued):

Q. What is the third map or chart that you hold in your hand?

A. This chart or map which I hold in my hand, shows the location of surface samples of mud in Jamaica Bay. It also shows by the nature of the markings whether the sample was judged to be polluted, unpolluted, or whether the pollution was in doubt. These

locations and markings are also numbered in the same way as on those two previous maps, and the samples can be identified in the same way.

Mr. McCarter: The same objection.

The Commissioner: Note the objection.

Mr. O'Sullivan: I offer this chart or map showing the locations from which samples were obtained in Jamaica Bay and subjected to microscopical examination by this witness, which were plotted, not only the location, but the expressed opinion on the results of the examinations. I offer that in evidence and ask that it be marked Complainants' Exhibit No. 102.

Mr. McCarter: The same objection.

1691 The Commissioner: Note the objection. Received and marked Complainants' Exhibit No. 102.

Marked Complainants' Exhibit No. 102.

Q. In conducting your microscopical examination, Mr. Hoyt did you prepare slides?

A. I prepared one slide for each examination where pollution was thought to be probable, unless the microscopical appearance of the debris left me without doubt as to the pollution. I also prepared a certain number of permanent slides, which I now hold in my hand, some taken from mud samples at different locations. Each slide is labeled, and some are from debris of sewage, one from human feces, one from manure and two from other material, which would be likely to be found in sewage.

Q. Will you describe for the purpose of the record, what you mean by the term "slide"; describe what a slide is?

A. A slide is a piece of glass about 1-16 of an inch in thickness and about 1 inch in width and 3 inches in length, on which material which is to be examined under the microscope is placed for examination.

Q. And how is it kept in permanently good condition, such as the samples on the slides that you now have here?

A. These slides were kept in permanent condition by placing a small amount of Canada Balsam on the material on the slide and placing over the material a thin sheet of glass, and allowing the balsam to harden.

Cross-examination by Mr. McCarter:

Q. Mr. Hoyt, you spoke at the outset of your interesting examination of pathogenic bacteria?

A. Yes sir.

Q. How many bacteria in round numbers, are there, known to exist, different types or classes?

A. Do you mean all kinds of pathogenic?

Q. All kinds, first?

A. I cannot give them off hand.

Q. Well, roughly?

A. It would be so very rough, that I doubt whether it would have any value.

Q. What proportion of those that are known would you say are pathogenic?

A. It is a very small proportion. I do not think any mathematical ratio I would ascribe just now would be of any great
1692 value.

Q. By "pathogenic" what do you mean?

A. By "pathogenic" I mean disease producing.

Q. So that the disease producing bacteria are a very small proportion of all bacteria?

A. They are.

Q. How many samples of mud either from the bottom or below the surface were collected totally by you?

A. Collected or examined?

Q. Examined by you?

A. The exact number I could not give you without reference to the records. Roughly I will say from 600 to 1100.

Q. And the sample would be brought to you in a jar?

A. It would be.

Q. As I understand, you would then first wash and clarify the sample, taking off the mud and other things, and would choose what you considered a probably satisfactory hope for a specimen of debris?

A. Yes.

Q. How would you determine whether a piece of mud, did or did not contain debris at first?

A. All the mud in each bottle was washed out and strained and so washed free from mud that its nature could be pretty closely determined. That is glumes were so washed free from mud that they are recognized as glumes. Hairs were washed so free from mud that they were recognized as either hairs or else particles very similar in appearance. Bits of newspaper were washed so free from mud that they could be picked out as such. Bits of wood, other specimens, bits of material which were not regarded as indicating pollution were also washed. Everything was so washed free from mud that we could determine in a general way, what its nature was, and then out of that clean debris were picked those particular particles which seemed to be of importance. A large piece of wood evidently was of no importance, so it was not picked out for examination. Small hairs, evidently animal hairs, were important, so that were picked out for examination.

Q. Well, what would you consider interesting specimens, anything besides glumes, hairs, and bits of newspaper?

A. Bits of fruit skins.

Q. Anything else?

A. Glumes, animal hair, bits of newspaper and fruit skins, also the seeds of such fruit as tomatoes—such vegetables as toma-
1693 toes and other seeds were occasionally found.

Q. How large were these samples when they came to you first?

A. They were one pint samples; that is, they came in a one pint jar. The jar was not always entirely full.

Q. And when you undertook to treat your sample, the first thing you did was to wash it in the manner you have described?

A. Yes.

Q. And by that means separated what you call the mud from the debris or other important particles?

A. Yes.

Q. You assumed and were instructed by the commission to assume, as I understand it, that any specimens containing glumes, hairs or newspapers—that those showed evidence of pollution?

A. I did not assume that because I was so instructed. I assumed that on various grounds. Are you interested to know the grounds?

Q. Yes.

A. I assumed that partly on the ground of my examination, my own personal examination of debris from sewage which I obtained and from examination of the debris, washed free from human feces and from manure. I assumed it partly because Dr. Pond, after a careful study, and other experts, after a similar study had also come to that same conclusion, but I made independent and personal study as a result of which I came personally to the conclusion that these particles did indicate pollution.

Q. How do you account for the fact that they became imbedded some times one foot deep and sometimes ten or twelve feet below the surface of the bottom, rather than being either carried along on the currents or else resting on the surface itself?

A. The other observations of these deposits, as well as the microscopic examination of the debris, led to the conclusion that the deposits were of solid matter from sewage and the exact method of their deposition and the reason for the deposition, I did not inquire into.

Q. Well, do not you think it is rather remarkable that you should have found evidence of pollution, as you call it, 10 or 12 feet below the surface of the bottom of New York Bay?

1694 A. Taking into consideration the locations and the pollution near those points, I was not greatly surprised.

Q. What is the consistency of the bottom at these points?

A. The bottom is a soft slimy foul mud.

Q. How did you do these borings?

A. These borings I did not make myself. They were performed by thrusting this pipe which I have described very roughly down into this soft deposit. On the end of the pipe was a long handle to make this as easy as possible. Then when the pipe was pulled up, inside of this pipe was found a core of mud. That core was carefully scraped clean, the surface scraped off.

Q. Is the location of these subsurface specimens given on the analysis here?

A. It is given in these tables which have been submitted as evidence.

Q. How does the specific gravity of polluted matter compare with the specific gravity of unpolluted matter that you would find at the bottom of the river or bay?

A. You mean the solid particles?

Q. Yes.

A. I did not determine that.

Q. Will these specimens of debris, as you call them, remain for any considerable length of time in that semi-solid condition, or will they gradually become disintegrated and liquify?

A. I performed experiments myself to determine that very question. Experiments were also performed by Dr. Parsons and others connected with the Metropolitan Sewerage Commission. We found that the glumes and animal hairs and most of those particles which were used in determining whether a sample was polluted or not, resisted disintegration for a long while.

Q. About how long?

A. They resisted as long as they were—the examination which I made myself—I do not exactly remember the time when it was,—several months—and other examinations were made covering a much longer period. The changes were so slight as to indicate that the material would remain almost indefinitely in certain cases without disintegration.

Q. How do you differentiate newspapers in such small 1695 particles, from ordinary paper?

A. Newspaper was differentiated partly by the printing, partly by the coarseness of the texture.

Q. Can you read the account of the Titantic disaster on one of those specimens on that microscopic plate?

A. The sections of newspaper found were generally small, perhaps one eighth of an inch, something like that, but it was often possible to make out the letters, one or two letters were often found very clearly visible, on the sheet of paper.

Q. With the use of the microscope?

A. With the use of the naked eye. I do not know whether any of those in which that was true are here, but I remember very distinctly that that was the case.

(Witness examines slides.)

A. (Continuing:) I do not seem to have any samples here.

Q. It is not your idea, is it, that the presence of newspaper necessarily betokens human feces; is not there a large quantity of newspaper waste that is entirely devoid of feces, that is just thrown away?

A. There is, and if you remember, I discussed that in this report from which I have read.

Q. How do you differentiate in your newspaper specimens between those thus used and those that were used for toilet paper?

A. We did not attempt to differentiate. That is the presence of newspapers was not regarded as conclusive evidence that the sample was polluted or unpolluted. We merely regarded it as a certain indication that is, it caused suspicion, but was not anything like conclusive evidence.

Q. So far then as the presence in polluted matter of the human feces is concerned, you judge from the possibility of newspaper having been used in place of toilet paper or from the presence of human

hair, that that indicates human feces. Does not the hair come more from the bath?

A. I judged that hair indicated sewage pollution, because hair was found in large quantities in sewage, and because from personal observation plumbing is often stopped up with human hair. It is often found in the bath tub after taking a bath and from many standpoints, it is very evident that human hair was found in
1696 considerable quantity in sewage.

Q. What do you mean by sewage?

A. By sewage I mean the liquid and solid waste which flows from houses and factories into the sewerage system, and also, in the case of New York City of street sweepings and other material which is washed or swept into the storm drainage and is mixed with other sewage.

Q. New York has a separate system in that respect, has it?

A. It has a combined system.

Q. So far as the specimens of what you call pollution were found and recognized in the Upper and Lower Bay and in the neighborhood of Manhattan, you concluded that the bulk of it came from where? From Manhattan?

A. I made no study and wrote no report on the source of the sewage. Sewage is swept in and out of the harbor as you know, back and forth and it would be difficult to determine the source of the pollution, especially well out in the harbor.

Q. Of course, where you found it worse near a dock end, you had no doubt where that came from?

A. I judge it probably mostly came from a nearby sewer.

Redirect examination by Mr. O'Sullivan:

Q. In using the term "sewage" do you include domestic sewage and trade waste?

A. I do include all matter which flows out through the sewers.

Q. Whether it comes from factories or from houses?

A. I do.

Q. There are a great many thousand kinds of bacteria, are there not, Mr. Hoyt?

A. The number of species which have actually been classified—I doubt whether they are much in excess of a thousand, but any estimate which I might give as to the exact number, would not be very valuable.

Q. Pathogenic bacteria are those that infect and begin disease?

A. They are.

Q. Did you hear Dr. Parsons testify as to how his samples of mud, which were submitted to your analyses were collected?

A. I did not.

1697 Recross-examination by Mr. McCarter:

Q. Are you able by the naked eye to differentiate between human hair and hair from other animals?

A. No, I am not.

Q. Can you microscopically?

A. In some cases, yes, but no attempt was made to make such differentiation in my findings.

Q. The presence of the hair of any animal, human or otherwise, would be evidence of what you call pollution?

A. Unless it was evident that it was not human hair. Generally no distinction was made. Simply animal hair was found and animal hair was regarded as indicating pollution.

MAX L. BERREY a witness called on behalf of the Complainants, recalled for further examination, testified as follows:

Direct examination by Mr. O'Sullivan:

Q. Mr. Berrey, you are draftsman of the Metropolitan Sewerage Commission?

A. Yes, sir.

Q. I show you exhibits numbers 100, 101 and 102, and ask who did the plottings, the original plottings from which these photographs were taken?

A. I plotted the location of samples on these exhibits. I did all the plotting, showing the location of samples shown on Complainants' exhibits 100, 101 and 102.

Q. What data did you work on in making plottings, and who furnished it?

A. I worked on the original notes. They were handed to me. They were taken by the bacteriologists who collected the samples and analyzed the same.

Q. What did you do with the sextant readings in making your plottings?

A. I took their readings and with the use of instruments I plotted them on to these original maps, from which these photographs were taken.

Q. And these photographs were made at the instance of the Metropolitan Sewerage Commission, were they?

1095 —. Yes, sir.

Q. I show you Complainants' Exhibit No. 94, being oxygen tables for 1911, and ask if you plotted the locations from which these samples were taken?

A. I plotted the locations at which the samples were taken of dissolved oxygen, as shown on these tables in 1911.

Q. Have you a blue print of these plottings for the oxygen determinations made in 1911?

A. I have in my hand a blue print which shows the approximate location at which samples were collected to determine the dissolved oxygen figure in 1911.

Q. Who made the plottings?

A. I plotted these.

Q. And from the data that was furnished by the observers, as you have described?

A. Yes, sir.

Mr. O'Sullivan: I offer in evidence the chart showing the plottings

of the locations at which samples of water were taken with the oxygen determinations as exhibited in Complainants' Exhibit No. 94, I offer this in evidence, and ask that it be marked Complainants' Exhibit No. 103.

The Commissioner: Received and marked Exhibit No. 103.

Marked Complainants' Exhibit No. 103.

Q. I ask you, Mr. Berrey, if the oxygen determinations testified to and offered in evidence as Complainants' Exhibit No. 31 were plotted by you on any chart or map?

A. I have in my hand a blue print from the original, which shows the approximate locations at which samples of water were taken for oxygen determinations in 1909.

Q. Made by whom?

A. Made by Dr. Parsons.

Q. And by whom was the plotting done?

A. The plotting was done by me.

Q. From data furnished by whom?

A. Data furnished by Dr. Parsons.

Mr. O'Sullivan: I offer in evidence chart or map showing the plotted locations from which the samples were taken on the subject of oxygen determinations for the year 1909 and ask that it be marked in evidence as Complainants' Exhibit No. 104.

The Commissioner: Received and marked Complainants' Exhibit No. 104.

Marked Complainants' Exhibit No. 104.

Q. Mr. Berrey, did you prepare any chart or map showing
1699 the plottings for which samples were taken for the determinations of the number of bacteria present during the year 1909?

A. I did.

Q. Where did you get your data for the plottings?

A. That was furnished me by Dr. Parsons.

Q. Have you got that chart or map with you?

A. Yes, I have in my hand a blue print showing the approximate locations at which samples of water were taken, to determine the number of bacteria, contained therein, during the year 1909.

Q. And does this chart or map show the locations of the 1,162 samples taken?

A. Approximately.

Mr. O'Sullivan: I offer that in evidence and ask that it be marked Complainants' Exhibit No. 105.

The Commissioner: Received and marked Complainants' Exhibit No. 105.

Marked Complainants' Exhibit No. 105.

Q. Mr. Berrey, did you plot on a chart or map the 1,133 samples taken for the determination of the bacteria in the mud during the years 1907 and 1909?

A. I did.

Q. And have you got that chart or map with you?

A. This blue print is a print of the original, which shows the approximate location at which those samples were collected.
Q. Prepared by whom?
A. Prepared by myself.

Mr. O'Sullivan: I offer the chart or map prepared by this witness showing the locations at which the samples were taken for determination of the bacteria, in mud, during the years 1907 and 1909, I offer that in evidence, and ask that it be marked Complainants' Exhibit No. 106.
The Commissioner: Received and marked Complainants' Exhibit No. 106.
Marked Complainants' Exhibit No. 106.

Q. Mr. Berrey, did you plot the locations at which the 1,100 samples of mud were taken during the year 1909 and subjected to microscopical and bacterial examination?
A. I did.
Q. And do you now produce it?
A. This blue print before me is a print of the original, 1700 which shows the approximate locations, at which samples were collected for microscopic and bacterial examination in 1909.
Q. And from data furnished by whom?
A. By Dr. Pond and Dr. Parsons.

Mr. O'Sullivan: I offer this chart or map in evidence, showing the locations of mud samples, secured and testified to, and ask that it be marked Complainants' Exhibit No. 107.
The Commissioner: Received and marked Complainants' Exhibit No. 107.
Marked Complainants' Exhibit No. 107.
Mr. McCarter: Insofar as the plottings that have been offered and received in evidence, are the results then of the work of Dr. Pond, I am compelled to object, and at the proper time to move to strike them out because of the fact that Dr. Pond has not been here, and, unfortunately, cannot be to verify his work. With that preface, I will ask Mr. Berrey a few questions.

Cross-examination by Mr. McCarter:

Q. Are you able to differentiate on the plottings, Mr. Berry, the work of Dr. Pond from the work of the other observers?
A. Not on the chart itself.
Q. I noticed that you were quite careful to say in each case that you gave the approximate location. Will you describe just how you did this work of plotting?
A. I did not use the word "approximate" on all of the exhibits.
Q. Why did you differentiate in some between the accuracy and the approximate accuracy of a plotting?
A. Because a part of these exhibits just handled by me, some of them are photographs of exact plottings. Others are intended only to be approximate.

Q. And you were careful to make the distinction in your evidence, so that that will appear as to which class they belong?

A. Yes.

Q. Was the original plotting done on maps of the size of these blue prints or photographs that are produced or larger maps?

A. Larger maps.

Q. Very much larger?

A. Yes.

Q. How were these reduced in size?

1701 A. These blue prints are prints of the original plottings; these which were photographed were reduced through a process of photographing.

Q. And the blue prints which are marked respectively Exhibits Nos. 103 to 107 inclusive, are prints of the original plottings, or are they reductions?

A. They are prints of original plottings.

Q. Are they accurate or approximate.

A. Approximate.

Q. You could not accurately plot on so small a scale, could you?

A. No, indeed.

Q. Within what degree of accuracy do you suppose they are in fact made, these exhibits last numbered?

A. They are intended only to show the approximate field covered in the investigations.

Q. The photographs which are numbered respectively 100 to 102 inclusive, you say they are accurate plottings?

A. Yes, sir.

Q. Is not the scale quite as small on them or nearly so?

A. That is reduced by a process of photographing from a much larger one.

Q. What do you call that process of reduction?

A. Photographic reduction.

Q. Now, in order to plot on the large map from which these last exhibits number 100 to 102 inclusive, are photographic reductions, how would you proceed?

A. If there were notes as a rule they gave angles to establish the points which were taken with instruments, either a sextant or a compass, in the field, and in the office those same angles were used and by the use of a three point protractor and by the use of the observation points, which were used in the field, and were shown on the original maps, the exact locations could be determined.

Q. How did you determine the distance having the angle and the point of observation, you yet had to have some distance, did you not, before you could locate it?

A. Where the angles were taken, there was no distance necessary.

At 4 P. M. adjourned to May 16th, 1912 at 10:30 o'clock A. M.
Adjourned to May 16th, 1912 at 10:30 A. M.

1702 Supreme Court of the United States, October Term, 1911.

THE PEOPLE OF THE STATE OF NEW YORK, Complainants,
against
THE STATE OF NEW JERSEY and THE PASSAIC VALLEY SEWERAGE COMMISSIONERS, Defendants.

CITY HALL, NEW YORK CITY,
May 16th, 1912—10:30 a. m.

Present: James D. Maher, Esq., Commissioner.

Appearances:

Dr. Wm. J. O'Sullivan, Special Counsel for the People of the State of New York.

Met pursuant to aljournment.

The hearing was resumed at 10:30 A. M. and after a wait of thirty minutes for Counsel for defendants and they not appearing, Mr. O'Sullivan produced a letter from Mr. Riker, Counsel for defendants, asking for a further postponement of the hearing for two weeks from the 15th instant, namely, Wednesday, May 29th, 1912.

Mr. O'Sullivan: Mr. Commissioner, while I have ever been anxious to accommodate Counsel for the defense, I am placed in an embarrassing position, by having already completed arrangements with eminent professional witnesses, who have made arrangements, some of them, to leave for Europe early in June, and who will not
1703 be available if I accede to this request for an adjournment until May 29th. I respectfully move you, sir, that adjournment be given at the furthest to May 22nd, 1912, at this chamber.

The Commissioner: The hearing will be adjourned until Wednesday, May 22nd 1912, at the request of Counsel for defendants. The hearings will be resumed in this chamber on that day at 10:30 A. M.

Adjourned to May 22, 1912, at 10:30 A. M.

1704 Supreme Court of the United States, October Term, 1911.

PEOPLE OF THE STATE OF NEW YORK, Complainants,
vs.
STATE OF NEW JERSEY and THE PASSAIC VALLEY SEWERAGE COMMISSION, Defendants.

CORPORATION COUNSEL'S OFFICE,
NEW YORK, June 5, 1912—10:30 a. m.

Present: James D. Maher, Esq., Commissioner.

Appearances:

Dr. Wm. J. O'Sullivan, Special Counsel for the people of the State of New York, complainants.

Adrian Riker, Esq., for the Passaic Valley Sewerage Commission, defendants.

Met pursuant to adjournment.

LINSLY R. WILLIAMS a witness called on behalf of Complainants, being first duly sworn, testified as follows:

Direct examination by Mr. O'Sullivan:

Q. What is your name, Doctor?
A. Williams, Linsly R.
Q. Where do you reside?
A. 882 Park Avenue.
Q. Are you in the active practice of medicine?
A. Yes.
Q. Where did you graduate, Doctor?
A. From the College of Physicians and Surgeons, Medical Department of Columbia University, City of New York.

1705 Q. Where did you do your academic study?
A. At Princeton, New Jersey.
Q. Graduating in what year?
A. I graduated in 1895 with the degree of A. B.
Q. Did you take any course of study in Germany?
A. In part,—one semester in Griefswald in 1896, and a voluntary course in Munich in 1909, 3 months only.
Q. What degree did you take from Columbia?
A. A. M. and M. D.
Q. What hospital course did you take, if any?
A. I was at the Presbyterian Hospital in the City of New York for two years, graduating from there in 1902, and I was also at the Sloane Maternity Hospital for three months. I graduated in the summer of 1902.
Q. Did you study any where else in Germany besides the two places that you have mentioned?
A. Greifswald and Munich were the only places.

Q. Have you been attached to any of our hospitals here?

A. Yes. I was Assistant in Medicine at the Vanderbilt Clinic for three years and Chief of the Medical Department there for four years following, and I was Visiting Physician to the Seton Hospital for Consumptives for three years, the House of Rest for Consumptives for three years and for four years I was Visiting Physician to the Sea Breeze Hospital for Tubercular Children at Coney Island, and for the last seven years, Assistant and finally full Visiting Physician at the City Hospital of the Department of Charities in the City of New York.

Q. Are you connected with any of our Public Health or Medical Societies?

A. Yes. I am a member of the New York County Medical Society; I am Chairman of its Committee on Public Health. I am also a member of the Academy of Medicine, and a member of its Executive Committee on Public Health. I belong to several other less well known Medical Societies.

Q. Are you associated in any of the Medical Departments of Columbia University?

A. Yes, I teach in the Medical Department of Columbia University, have, since 1903, in the Pathological Department one year, and since then in the Medical Department, with the title of Associate in Clinical Medicine at the present time.

1706 Q. Are you attached to any of our hospitals in the capacity of Visiting Physician or otherwise?

A. Only the one just mentioned, the City Hospital, I am Visiting Physician.

Q. Are you a member of any of our eleemosynary or philanthropic institutions for improving the condition of the poor sick otherwise?

A. I have been on a number of committees on charitable work. One in which I am interested at the present time—I am a Member of the Board of Managers of the New York Association for Improving the Condition of the Poor.

Q. Did you mention the Societies, the Medical Societies, that you held membership in?

A. I have mentioned two, the County Medical Society and the Academy of Medicine.

Q. Is there a Society of Internal Medicine?

A. Yes.

Q. Are you a member of that?

A. Yes.

Q. Are you a member of the American Medical Association?

A. Yes.

Q. Are you a member of the Association for the Prevention of Tuberculosis?

A. The National Association, yes.

Q. Have you become interested in that to the extent of becoming a member of any Committee that had to do with food production, that would be likely to transmit tuberculosis like milk, for instance?

A. Yes, I was a member for four years of the New York Milk Committee.

Q. Have you contributed to the literature of your profession, Doctor, either by articles or papers, matters of that kind?

A. Yes, I have written several articles on the Physical Welfare of School Children and the treatment of Tuberculosis, and the condition of the Milk Supply.

Q. Are you connected with any of our Municipal Departments?

A. Yes, I am a member of the Metropolitan Sewerage Commission of New York.

Q. And have been for how long?

A. Since January 1908.

Q. Have you had occasion to investigate the amount of infectious and contagious diseases that exist in the metropolitan district?

A. Yes.

Q. Will you state what the results of your investigations have been?

Mr. Riker: I object to the question on the ground that it is immaterial and irrelevant.

1707 The Commissioner: Note the objection.

A. I can give you the figures for Greater New York for 1908, which I have compiled from the 1908 report of the New York City Department of Health.

Mr. Riker: I object to the answer as it appears it is not based upon his own researches; it is hearsay.

Q. Proceed, Doctor.

A. This gives the number of cases that existed in that year in Greater New York. The reports for Westchester County have been compiled by the New York State Department of Health. They are not full reports of the number of cases of infectious diseases, but reports of the deaths from these diseases in the various towns of Westchester County.

Q. Do physicians have to report these diseases to the Department of Health of this City and State?

A. They do in the City.

Q. And to the State Department of Health?

A. They do in the City, but reports for cases in Westchester County have not been published.

Mr. Riker: I would like to ask the witness a question.

Mr. O'Sullivan: All right, sir.

Cross-examination by Mr. Riker:

Q. What have you before you that you are testifying to in the way of records?

A. I have got some of my own minutes and notes that I have made from study of these various Health Department Reports.

Q. You have not the original Reports?

A. Not with me.

Mr. Riker: I object to the testimony on the ground that it is not based on any official report or on his own researches.

The Commissioner: Note the objection.

Direct examination by Mr. O'Sullivan (resumed):

Q. Doctor, the reports of the City Department of Health, do you mean the official reports?

A. Yes.

Q. Based upon the reports of physicians?

A. Yes.

Q. Compiled and issued as an official document by the City Department of Health?

A. Yes.

1708 Q. You may proceed, Doctor.

A. I have compiled for Westchester County the approximate number of cases which should have existed in order to produce the mortality for that year, and similarly a table for the six northern counties of the State of New Jersey, all of which comprises part of the Metropolitan Sewerage District, as outlined by the Metropolitan Sewerage Commission.

Q. What counties?

A. These are the counties: Bergen, Essex, Middlesex, Hudson, Passaic and Union. These figures were compiled from the data given in the published report of the New Jersey State Department of Health for the year 1908.

Q. An official report?

A. Yes. I have compiled the figures of the number of cases of contagious and infectious diseases in the City of New York and the County of Westchester, and in the Counties of New Jersey in the Metropolitan District, for the year 1908. Will I read those tables?

Mr. Riker: Just a few questions before you put them in?

Cross-examination by Mr. Riker:

Q. This Sheet marked 2, Doctor, that is taken from the official report?

A. The figures are taken, the table is not taken bodily.

Q. I understand, but it is based on the official reports?

A. Yes.

Q. And these figures here are a compilation made by you from those reports?

A. I think in the main they are copied directly from the report.

Q. In any respects are they compilations?

A. There may have been several places in the report where the figures have been added together by me.

Q. And this is the result of your examination of the original report as I understand it?

A. Yes.

Q. And not an estimate?

A. No, not an estimate.

Q. Sheet No. 3, for Westchester County, do I understand that is an estimate?

A. Part of it is an estimate. The deaths are; those are given in the report, and the number of cases are estimated, as stated on the
1709 paper, they are estimated.

Q. You mean by that, that taking the number of deaths, you have estimated——

A. How many cases there were.

Q. How many there should have been in order to have that percentage of deaths?

A. Yes.

Q. And Sheet No. 4, is this based upon the New Jersey Reports?

A. Yes; that is similar to Westchester County.

Q. That is an estimate?

A. The deaths are given in the New Jersey Reports, but the number of cases are estimated.

Q. And Sheet No. 5, what is that?

A. The first part, the figures for 1909, in the City of New York.

Q. And those are from what?

A. Those were taken from the Department Report.

Q. No additions, that is as they appear?

A. That is as they appear.

Mr. Riker: I object to the matter that is embodied in Sheet No. 2 on the ground that the original records are the best evidence, and that the sheet itself, or the contents of it is hearsay. As to the matters on Sheet No. 3 I object on the same ground as to part, and as to the rest on the ground that it is mere hearsay on the part of this witness of the number of diseases that would produce the number of deaths stated to have been taken from the original reports and I make the same objection to the matter contained in Sheet No. 4 and Sheet No. 5 is also objected to on the same ground as I objected to Sheet No. 2 and the matters therein contained.

The Commissioner: Note all the objections.

Direct examination by Mr. O'Sullivan (resumed):

Q. State the contents of those tables?

A. These tables read as follows:

Number of Cases of Contagious Diseases Reported in 1908 in the City of New York.

	Borough—					
	Manhattan.	Brooklyn.	The Bronx.	Queens.	Richmond.	Total.
Population, 1900	1,850,093	1,166,582	175,422	152,999	21,441	3,847,557
Diptheria & croup	10,264	5,451	1,648	885	284	18,531
Measles	18,264	8,707	4,612	1,897	696	34,176
Smallpox	6	6	2	3	..	17
Scarlet Fever	12,057	8,121	2,529	1,296	417	24,420
Whooping cough	467	414	133	36	122	1,172
Chickenpox	2,781	2,045	710	297	158	5,991
German measles	544	152	53	43	31	823
Mumps	1,372	489	40	16	114	2,031
Totals	45,754	25,385	9,727	4,473	1,822	87,161

1711 *Number of Deaths and Estimated Number of Cases of Communicable Diseases in Westchester County, New York, in 1908.*

	Population by State census, 1905.	Typhoid fever.	Scarlet fever.	Measles.	Whooping cough.	Diarrhœa.	Tuberculosis.	Total.
Westchester County	28,000	20	45	28	13	332	410	888
Eastchester	3,980	1	..	4	..	8	4	18
Greenburgh	1,902	..	..	5	..	2	10	17
Mt. Vernon	25,006	2	4	6	4	39	35	90
New Rochelle	20,480	7	4	1	..	21	24	57
Pelham	1,840	..	1	..	..	3	..	4
Scarsdale	1,016	..	..	..	..	1	2	3
White Plains	12,120	3	1	..	..	12	18	33
Yonkers	69,503	7	24	2	3	147	116	299
Total	164,775	79	79	46	20	565	619	1,408
Percentage Mortality, the City of New York, 1908.		8%	5.4%	2.8%	2.6%	...	3%	
Estimated number of cases in above mentioned county and towns		987	1,463	1,643	769	...	1,857	

Number of Deaths and Estimated Number of Cases of Contagious and Communicable Diseases in the Counties in New Jersey of the Metropolitan District in 1907.

	Population by State census, 1905.	Deaths 1907. Typhoid fever.	Measles.	Scarlet fever.	Whooping cough.	Diphtheria.	Tuberculosis.	Total.
Bergen County	100,008	14	9	5	17	19	122	186
Essex County	409,028	66	19	52	46	119	1,059	1,381
Hudson County	449,679	75	63	146	46	107	1,113	1,610
Middlesex County	97,008	20	4	9	15	30	141	219
Passaic County	178,058	22	18	25	9	44	302	420
Union County	117,211	17	8	21	20	65	221	349
Total	1,348,915	234	117	288	153	444	2,968	4,174
Mortality, County of New York, 1907		8%	2.2%	5.4%	2.6%	10%	3%	
Number of cases in New Jersey Counties		2,925	5,318	4,777	5,884	4,440	8,904	

1712

Mortality, County of New York, 1907..	8%	2.2%	5.4%	2.6%	10%	3%
Number of cases in New Jersey Counties	2925	5318	4777	5884	4440	8904

For the year 1909 there were 72,073 cases of infectious diseases in the City of New York divided as follows:

Dip-theria and croup	15,097
Scarlet fever	12,475
Measles	31,954
Small pox	9
Chicken pox	6,765
Whooping cough	2,752
Mumps	2,438
German measles	582

Of communicable diseases there were reported in the year 1909:

Tuberculosis	25,067
Typhoid fever	3,499
Cerebro-spinal meningitis	346

These latter figures are derived from the annual report of the Department of Health for the year 1909.

As Nassau County is in the drainage district of Greater New York, I have also added a number of cases of infectious and contagious diseases, which occurred in that county during the year 1908.

There has never been any reporting of veneral diseases, although they are infectious, and it is not possible to estimate the number.

Q. Did you compare the figures that you have just testified to relative to the population, deaths and the other features embodied in that testimony with the original figures in the official reports?

A. Except the portions of Westchester County and New Jersey which was approximated. The others were compared.

Q. What did you base your estimate there on?

A. Upon taking the average percentage of deaths for the City of New York, and then having the average number of
1713 deaths, the average morbidity, as it is called, for the City of New York by a simple arithmetical calculation, I made out what the number of cases in New Jersey were.

Q. Is that a recognised method of making these computations among physicians?

A. Yes, it is.

Q. Taking the figures for tuberculosis, typhoid fever, cerebro-spinal meningitis, where did you derive these figures from on page 5?

A. Those are from the Department of Health Reports in 1909.
Q. The year 1909?
A. Yes.
Q. Is Nassau County in the drainage district of Greater New York?
A. A small part of it is, yes.
Q. Did that influence you in arriving at the number of infectious and contagious diseases, which occurred in that county in 1908?
A. Yes, but it is rather a negligible factor, I should say. A very small area there.
Q. Were there any of the infectious diseases which are not reported, like the venereal diseases?
A. Yes, a large number of them.
Q. And those you would make no estimate on?
A. It would be purely a guess.
Q. Is there any doubt of their infectious character?
A. Not in the least.
Q. In using that term "disease", what do you mean by the term "disease" itself, as you employ it?
A. It is really only a name which is applied to a definite complex of symptoms which occur as the result of a functional or organic change in the body.
Q. Now what do you mean by the term "infectious diseases"?
A. An infectious disease is one which is transmitted from one animal to another by specific micro-organisms, which organism must be isolated in pure culture and having been isolated in pure culture, must be able to reproduce the same disease in another animal of the same species.
Q. Now, having defined infectious disease, what do you mean by the term "contagious diseases"?
A. A contagious disease is merely an infectious disease which is more readily communicable than others.
Q. Is there any danger of infection from the discharges or fomites of patients suffering from these communicable
1714 diseases?
A. Yes, some of the diseases, yes.
Q. What do you mean by fomites?
A. The clothing and implements, utensils, anything that has come in contact with the patient.
Q. Are the discharges from patients suffering from infectious diseases when entering our harbor waters liable to produce the same disease in other people who come in contact with them?

Mr. Riker: I object to that on the ground that this witness is not qualified as an expert as to the effect upon water of these discharges.

The Commissioner: Note the objection.

A. Yes, I think they may.
Q. If these fomites come in contact with healthy people, are

they liable to produce the disease in them from which the patient suffers?

A. In some instances, yes.

Q. Will you name some of the diseases that are sources of danger in the manner I have just described?

A. Typhoid fever, tuberculosis.

Q. Any others?

A. Pneumonia, meningitis.

Q. Diptheria?

A. Diptheria.

Q. Conjunctivitis?

A. Yes.

Q. Why do you regard these diseases as dangerous and communicable under the conditions I have described?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. You mean as regards the water?

Q. Yes.

A. Because I think it is possible and that it happens, that these diseases occur as the result of water coming in contact with healthy people.

Q. Well, take the bacillus typhosus, will that exist in our harbor water for any length of time?

A. Yes.

Q. And will it produce typhoid fever in one with whom it comes in contact?

A. If it is taken in the alimentary tract.

1715 Q. If they swallow the water when they are bathing in it?

A. Yes.

Q. Is it an accepted medical fact that the germs of these infectious diseases that you mentioned will live outside of the human body?

A. Yes.

Q. And will live in water?

A. Yes.

Q. And in sewage?

A. Yes.

Q. Is typhoid fever more prevalent in this city than in other cities?

A. Yes, there are some cities in this country, which have as high a rate, but they are rather higher than most of the Continental cities.

Q. Has any one compiled the death rate and the percentage of disease of say typhoid fever for the various cities of this Continent?

A. There have been a good many tables prepared from the Department of Health reports of the different cities. There is one table that I found in a text book by Mr. Whipple which gives the

typhoid rate, the typhoid fever deaths in various cities in this country and abroad.

Q. You mean Mr. George C. Whipple?

A. Yes.

Q. Who has written a book on typhoid fever?

A. Yes.

Q. And you say he has published a table?

A. Yes.

Q. Dealing with what features of typhoid?

A. With the number of deaths per hundred thousand people living in various American and foreign cities *per* the years 1898 to 1907.

Q. What does that table show relative to European cities as to the death rate from typhoid?

Mr. Riker: I object to it on the ground that it is not evidence of the character, as now proved, that is admissible in this cause, and it is irrelevant and immaterial.

The Commissioner: Note the objection.

Q. Does it show there higher or lower?

Mr. Riker: I object to that on the same ground.

The Commissioner: Note the objection.

A. The rate for New York is higher than almost any of the foreign cities, with the exception of Paris for two years, 1899 and 1900, the foreign cities being London, Paris, Berlin, Vienna
1716 and Dresden.

Q. Doctor, does Mr. Whipple in his work on typhoid fever, from which you say you have copied this table, state that he took these figures from official sources?

A. I believe so. I could not remember that definitely.

Q. I will ask you, Doctor, to read the figures from Mr. Whipple's figures relative to typhoid fever deaths in seventeen cities where he has based his estimate per one hundred thousand.

Mr. Riker: I shall object first on the ground that Mr. Whipple's publication is not evidential in this cause, not being an original record of the disease in the different cities, from which it is proposed to put in testimony, and that the evidence is immaterial, irrelevant and incompetent in this cause.

The Commissioner: Note the objection.

A. The table is as follows:

1717 *Typhoid Fever Deaths in 17 Cities per 100,000 Living.*

Year.	American Cities.												Foreign Cities.				
	Baltimore.	Boston.	Chicago.	Cleveland.	Indianapolis.	Louisville.	New York.	Philadelphia.	Pittsburgh.	St. Louis.	Washington.	San Francisco.	London.	Paris.	Berlin.	Vienna.	Dresden.
1898	37.1	33.	37.6	31.8	28.4	57.7	20.7	49.4	68.	16.5	60.6	16.7	13.	9.9	4.3	6.8	4.3
1899	30.1	29.4	26.	28.6	37.8	59.8	16.3	73.4	106.9	22.8	60.7	51.2	17.8	29.	4.1	4.1	7.3
1900	37.1	25.6	19.9	53.8	43.7	57.8	20.8	34.7	144.2	29.2	77.8	41.3	16.5	34.6	5.8	8.3	4.1
1901	28.7	23.8	29.8	34.9	33.1	46.	20.6	34.6	123.8	33.4	61.4	25.1	12.1	13.7	4.7	4.5	6.4
1902	42.	22.1	45.1	35.5	44.5	60.3	20.3	47.3	140.6	40.	79.1	29.6	12.8	....	2.7	3.	4.
1903	35.	20.5	32.1	115.	51.1	59.8	17.1	72.6	136.5	52.4	48.8	25.	8.6	10.4	3.2	3.9	5.3
1904	37.5	23.6	20.2	49.6	68.4	61.6	16.8	55.	139.4	37.9	47.	31.4	6.2	12.2	3.7	3.4	2.8
1905	35.7	20.8	16.5	14.9	30.2	49.4	16.	51.	107.9	22.6	48.2	23.9	5.2	....	5.3	4.4	3.7
1906	34.3	21.6	18.3	20.2	39.2	67.7	15.4	74.8	141.3	18.3	52.3	....	6.	11.	4.	5.	7.
1907	41.3	10.5	17.7	18.9	29.4	67.9	17.5	60.7	130.8	16.3	35.5	....	4.	10.	4.	3.	2.

1718 Q. Is typhoid endemic in New York City?
A. Yes.
Q. Describe what you mean by the term "endemic"?
A. An infectious disease which is always present in one locality.
Q. Is any attempt made to prevent the discharge from the typhoid patients or other patients suffering from infectious diseases, from going into sewers in New York City and adjacent territory?

Mr. Riker: I object on the ground that this witness is not competent to testify as to conditions which are not within his own knowledge.
The Commissioner: Note the objection.

A. As a physician practicing in New York City, whenever I report a case of contagious or infectious disease, the department of Health of the City of New York sends to me a printed copy of instructions informing me, and commanding me, to inform my patient how to disinfect the various discharges. They usually send a different circular for each different disease.
Q. And in those circulars does the Department of Health of this City prescribe the mode of disinfecting the discharges and the fomites of patients suffering from infectious diseases?
A. Yes, with a great deal of detail.
Q. Have you got one of those cards with you?

(Witness produces card.)

A. This is a Copy of Rules for the care of patients having or suspected of having typhoid or other communicable diseases.
Q. And does the Department of Health of this City describe and prescribe how the linen shall be cared for; how the dishes, the thermometers, bed pans, urinals, nurses' hands and personal effects shall be treated?
A. Yes, with complete detail.

Mr. Riker: I object to this as immaterial and irrelevant, as it does not appear that the instructions are as a matter of fact carried into effect.

Q. If the methods prescribed for the treatment of these discharges and the fomites of patients suffering from infectious diseases
1719 are carried out, will it satisfactorily destroy all germs?

Mr. Riker: I Object on the ground that the hypothesis is not based upon evidence in this cause.
Mr. O'Sullivan: Is based upon the experience of this physician.
The Commissioner: Note the objection.
Mr. O'Sullivan: He has just described that he reports an infectious disease to the City Health Department, and the Health Department prescribes how he shall treat each individual case as to the discharges, the linen, the dishes and other matters. I want to know what his experience is on the line of my question.

A. When the instructions are properly carried out, there is no

danger from the discharges or the utensils or other articles which come in contact with the patient.

Q. As a matter of practical importance is there difficulty in carrying out the disinfection prescribed by the City of New York Health Department.

Mr. Riker: I object on the ground that it is immaterial and irrelevant whether there are difficulties or not.

The Commissioner: Note the objection.

A. Yes, it is difficult in homes of the poor, and people in moderate circumstances, where they have not sufficient help, perhaps intelligence, to carry out the instructions, but in the hospitals the instructions are carried out usually with detail and care and satisfactorily.

Q. You have had hospital experience, you testified to that before?

A. Yes.

Q. Do they have difficulty on account of poorly paid orderlies?

A. In some hospitals, yes.

Q. From your hospital and other experience, Doctor, will you state whether the bacillus of typhoid fever and tuberculosis can reach the sewers in a virulent state?

A. Yes.

Q. Capable of producing infection?

A. Yes, they can.

Q. Is it still dangerous while in the harbor waters?

A. Yes.

Q. Do you know how long the typhoid bacillus can remain virulent in water?

1720 A. In fresh water, it may remain virulent for many weeks.

Q. How is it in sea water?

A. Also for many weeks.

Q. How is it in sewage?

A. They may live for some days in sewage, as many as six.

Q. Do you know whether or not efforts have ever been made to discover typhoid bacillus in harbor water here?

A. Yes, they have. They have been made by the Department of Health.

Q. Has typhoid bacillus ever been discovered from fresh water or milk which has definitely been proven to be the cause of a typhoid epidemic?

A. It is a very difficult technical problem to isolate typhoid bacilli from milk and water. It has been isolated in milk, but I do not think that it has been in the harbor water.

Q. Do tubercular bacilli find their way into our harbor waters?

A. Yes.

Q. How long can the tubercular bacilli retain their virulence in water?

A. A very long time. They have been found virulent after 2 to 10 months in water, and in sewage even after freezing.

Q. What diseases do you know can result from contamination of our harbor water?

A. Typhoid fever, diarrhœal diseases, and irritative diseases of the eye.

Q. Do you know of any definite cases which have occurred as the result of pollution of our waters?

A. Yes. A number of cases of typhoid fever have been caused by the eating of shell fish taken in the harbor waters.

Q. Where did these oysters come from?

A. From Jamaica Bay.

Q. Do you recall any definite epidemic occasioned by them?

A. Yes, there was an epidemic in the year 1905 in the towns of Lawrence and Inwood.

Q. Is oyster culture extensive within the metropolitan district?

A. Yes, there is a large amount of it in the Metropolitan District. In the year 1908, they produced 2,647,500 bushels of clams and oysters. 1, 794,077 of these were sent to the New York market.

Q. Have you made any estimate as to the approximate values of that large amount of shell fish?

A. I did not personally make any estimate, but the pub-
1721 lished reports of the Department of Commerce and Labor states that this catch had a value of $2,205,540.62.

Mr. Riker: I move to strike that answer out as not responsive, and not being within the knowledge of this witness, as hearsay.

The Commissioner: Note the objection.

Q. Were these the official figures of the Department of Commerce and Labor?

A. These figures are taken from the preliminary report of the Bureau of Census of the Department of Commerce and Labor for the year 1908.

Q. Taking the figures of the Census Bureau, what did they estimate the total value of the catch for the year 1908 as?

Mr. Riker: I object to it on the ground that the reports if relevant at all, are the best evidence in this cause.

The Commissioner: Note the objection.

A. The total value was estimated by this Bureau at $4,592,440 and the value of the shell fish, as just given was 60 per cent. of this total.

Q. In the report for the year 1908, is there set forth the amount of capital invested in the fishing industry both by New Jersey and New York for the Metropolitan District?

Mr. Riker: That question calls for yes or no.

Mr. O'Sullivan: Yes or no, Doctor.

A. I have the value for 1904 from the report, but I do not think that I have it for 1908.

Q. It has been gradually shrinking, has it?

A. I have not the figures of the value for 1908. I have it only for 1904. The total value of the catch was lower in 1908 than it was in 1904, but as to the amount of capital invested, I do not know the difference in those two years.

Q. In your investigations what practical interest had the shell fish industry of New York and New Jersey?

A. I was interested in it from two points of view. First from the danger of eating shell fish from within the limits of the harbor, and second the diminution in the value of the catches of shell

1722 fish and other fish taken within the harbor waters and its tributaries.

Q. Is this in line with your investigations of pollution by sewage of private areas and public reefs?

Mr. Riker: I object to the question. I do not quite see the connection.

Mr. O'Sullivan: I withdraw the question.

Q. Were you interested in the dissemination of disease, and to what extent it occurred by the handling and eating of sewage polluted shell fish.

Mr. Riker: I object to it on the ground that it is immaterial and irrelevant.

The Commissioner: Note the objection.

A. Yes, I was interested, because I wanted to be perfectly sure from a study of similar conditions in this country and abroad that the eating of sewage polluted shell fish was really a cause of typhoid fever.

Q. Have those matters been very fully investigated by the German and English scientists?

A. Yes, German, French, English, and in this country it has been shown to be a definite fact.

Q. What percentage of the shell fish industry of New York and New Jersey consists of the oyster trade?

A. About 95 per cent. of the shell fish industry is the oyster industry.

Q. And what you have said in regard to infection by sewage pollution of shell fish, does that apply to other shell fish than the oyster?

A. Yes, sir, it would apply to clams and mussels.

Q. Has the Metropolitan Sewerage Commission, as the result of its investigations reported the danger of shell fish as a food when taken from our harbor waters?

A. The matter has been gone over a good many times, but I am not sure whether any definite dictum has been published or not.

Q. Did Upper New York Bay ever support large oyster beds?

A. I believe that there used to be oysters beds below Liberty Island.

Q. Bedloe's Island and Staten Island?

A. Bedloe's was the former name of Liberty Island.

1723 Q. Are there many oysters now taken from these natural reefs?

A. Very few. Almost all the oysters are taken from planted beds.

Q. Have you investigated the value of the oyster industry the volume of its trade, and the volume of its product, in this Metropolitan District?

A. Yes, I have, taking the figures from the only official reports, the statistics.

Q. What counties in the Metropolitan district produced oysters and clams.

Mr. Riker: Any limit of time, at any time in the past?

Mr. O'Sullivan: Any time that his investigations cover?

A. Yes, in 1904, in New Jersey, in Bergen County they were not reported; in the County of Hudson the value of the oysters was $20,300; Middlesex County clams—$13,750; oysters $49,340, total $63,090. Monmouth County, clams $211,785, oysters $69,838, total $291,643, Union County, $6,240, oysters; total value of clams $225,535.; total value of oysters $145,738. Total value of oysters and clams for the northern Counties of New Jersey, $371,273.

Q. Now, taking New York, what percentage of the value of the shell fish was produced in the Metropolitan District?

A. 34 per cent. of the total value of the shell fish.

Q. And what percentage in New Jersey?

A. 10 per cent. of the total value of shell fish taken in New Jersey were taken in the Metropolitan District.

Q. Taking those values for 1906 in the harbor waters of the Metropolitan District, what do they amount to?

A. For New York, $965,600.84.

Q. In New Jersey?

A. New Jersey, 1904, $371,273.

Q. Have you included the value of the shore properties, boats and implements in those estimates?

A. That is purely the market value of the catches.

Q. Of the shell fish?

A. Yes.

Q. Has the Bureau of Marine Fishery taken interest in this Metropolitan Shell Fish Industry?

1724 Mr. Riker: I object to it as immaterial and irrelevant.

The Commissioner: Note the objection.

A. Yes, the Bureau of Marine Fisheries of the Forest Fish and Game Commission of the State of New York in their report for 1908 state that it is now unlawful to place or allow to run into waters in the vicinity of oyster beds, any sewage, sludge, acid or refuse, or substance injurious to oyster culture, and upon it appearing that oyster beds have become polluted from one or more of these causes, it becomes the duty of this Bureau to cause complaint to be made and a criminal action against the person or persons so offending. Such person is also liable in damages to the persons injured. It will at once be appreciated that the vast amount of sewage said to be 500,000,000 gallons every 24 hours, emptied into our tidal waters by the City of New York, is the most serious existing cause of pollution. In consequence of this situation, no oysters for use as food are taken from New York Bay, or have any oysters for the market been taken from these waters during the history

of the Shell Fisheries Department of the Forest, Fish and Game Commission. That is an extract from the report.

Q. What is the extent of the taking of clams from these waters?

A. It is a very difficult thing to measure, because so much of it is done by various individuals for their own personal use. You can see them taking clams almost any time in the summer from various parts of the East River and Jamaica Bay. Some of the figures were given some time ago on clams.

Q. Is there any evidence to show that the eating of shell fish taken from this polluted water causes disease?

A. Yes.

Q. Can epidemics be traced to their consumption as food?

A. The epidemic at large was traced to the eating of oysters.

Mr. Riker: You mean at Inwood and Lawrence?

The Witness: Yes.

Q. Now, Doctor, have any cases of disease occurred from bathing in the harbor waters?

A. I believe that cases of illness do occur as the result of
1725 bathing in the harbor waters, but it is one of those technical things that it is very hard to trace.

Q. You mean to prove?

A. Very hard to prove what the source of any communicable disease is.

Q. What diseases have occurred as the result of bathing in the polluted harbor waters, as differing from diseases which might occur from bathing in pure water?

Mr. Riker: I object to it on the ground that this witness has already said that he has only a belief without any foundation of actual proof.

The Commissioner: Note the objection.

A. Typhoid fever, diarrhœal diseases, purulent diseases of the eye, and the chain of evidence is complete: it is known that typhoid bacilli have gained entrance to the water; it is known that they will live for many days in fresh water or brackish water, and it is known that the taking of water infected with typhoid bacilli into the stomach will cause typhoid fever.

Q. And yet, with all these facts, could you prove a given case of typhoid was traceable to that water?

A. I do not think that you could prove it.

Q. Even though you were morally certain of it?

A. Would be morally sure of it, but could not prove it. The only way you can prove the cause of typhoid is to take some pure culture and squirt it under your skin or drink it. You will know where you got it then.

Q. Did you have occasion to investigate the amount of bathing that is done in our harbor waters and the bathing establishments?

A. Yes.

Q. Where are the majority of these bathing establishments.

A. There are two varieties of bathing establishments in the City. Those known as the floating baths and those known as the interior

baths. The floating baths are situated along the water front, especially along the shore of Manhattan and Brooklyn.

Q. As the result of your investigations on this particular line, did you issue a report of the pollution of the harbor waters used
1726 in the free floating baths for the year 1911, which was printed in the medical record?

A. Yes, I made such a report.

Q. Giving the data relative to the number of these baths?

A. Yes.

Q. Without giving the details of that, Doctor, does bathing take place to any marked extent in the harbor; that is do a large number of people avail themselves of the facilities?

A. Yes, a good many. The Department of Public Works keeps account of the number of baths taken in the free floating baths in the summer season, and in the year 1908, there were 2,413,961 baths taken. In 1909, there were slightly a smaller number.

Q. How many bathing establishments were there in which those baths were taken?

A. The City maintained 13 in 1908 and in 12 in 1909.

Q. Is any effort made to keep the water entering those baths particularly clean for bathing purposes?

A. Yes.

Q. What effort was made?

A. First there was legislative action taken in the year 1905 by the Legislature of New York, which regulates the sanitary condition of bathing establishments, and the preservation of life at bathing places. That Act reads as follows:

Mr. Riker: I object to the introduction of the Legislative Bill in this way as not the best evidence and immaterial and irrelevant to this inquiry.

The Commissioner: Note the objection.

Q. What chapter was that?

A. That is Chapter 454 of the Laws of New York of 1905.

Q. As a member of the Metropolitan Sewerage Commission had you to cognize the existence of that law?

A. I did.

Q. Did it govern your actions?

A. It did.

Q. State what the law was?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

1727 A. The law was as follows:

"Legislative action in 1905, chapter 454, laws of New York 1905, (Extract).

'Regulating the Sanitary Condition of Bathing Establishments and the preservation of Life at Bathing Places. It shall be unlawful for any person to maintain, either as owner or lessee, any bathing establishment of any kind, in this State, for the accommodation of persons, for pay, or any consideration, at a point less than five hun-

dred feet from any sewer connection emptying therein or thereat, so as to pollute in any way, the waters used by those using or hiring bathing houses at such bathing establishments; it shall be the duty of such owner or lessee to provide separate toilet rooms, with waterclosets properly provided with sanitary plumbing, constructed in a manner approved by the local board of health and in such a way as not to contaminate the waters used by the bathers; it shall be the duty of such owner or lessee to thoroughly wash and disinfect or cause to be thoroughly washed and disinfected, in a manner approved by the local board of health, all bathing suits that have been hired or used, before rehiring or permitting the use of the same again.'"

Q. Does this law apply to the free floating baths?

Mr. Riker: I object on the ground that this witness is not an expert as to the interpretation of the law.

Mr. O'Sullivan: I withdraw the question.

Q. Is the law enforced in regard to the private baths?

A. I believe not.

Q. Are there any other official precautions taken in addition to the ones prescribed in the law which you have just stated?

A. Yes, the Department of Public Works has to receive the assignment of a site from the Department of Docks and Ferries. They ask permission or rather the approval of the Department of Health for that site. When this approval is granted the bath is located at the designated site.

Q. Is any precaution taken by the proprietor or attendants at these baths to keep the water within the baths clean?

1728 A. There is an attempt made to keep out large particles of floating matter by keeping the slats, the boards through which the water comes, close together.

Q. Have any of these free floating baths been maintained at a site nearer than 500 feet of the sewer outlet?

A. Yes.

Q. Have you any figures to show this?

A. Yes. The situation of the baths for the year 1909 was obtained by the Sewerage Commission and the distance of each bath from the nearest sewer outlet was measured, and it was found that in a number of instances that the baths were much nearer than 500 feet to the nearest sewer outlet.

Q. Does it in your opinion, make any difference whether the bath is situated within the 500 feet of the sewer outlet or beyond that distance?

Mr. Riker: I object to it as immaterial and irrelevant.

The Commissioner: Note the objection.

A. The law states that the baths should not be situated within 500 feet of the sewer outlet, but the quality of the water is such that it makes very little difference in my judgment, whether it is 200 feet or 1,000 feet from the sewer outlet. Any larger distance, a

mile or two, might take you out to sea. Of course, that is a different story.

Q. Is that opinion based upon dye experiments and other investigations?

A. Yes, in part, partly on the dye experiments.

Q. Which Mr. Allen conducted and which he testified to?

A. Yes, I believe it was Mr. Allen.

Q. Taking the investigations of the commission on this 500 foot limit, what did they find as to the quality of the water in the bath?

Mr. Riker: I object to it on the ground that it calls for determinations of the witness, and that this witness does not appear to be the recognized official recorder of their determinations.

Mr. O'Sullivan: This witness was specially designated to make these investigations, Mr. Riker.

The Commissioner: Note the objection.

1729 A. The inspections were made of the floating baths and without going into any test further than what one could see with the naked eye, I can say that the water in practically all of the baths was polluted by sewage material and human excrement which was readily recognizable to the naked eye.

Q. Were experiments conducted to trace the sewage into the baths?

A. Yes, experiments were made by putting a dye into a neighboring sewer outlet and following the dye and seeing which direction it would go, and if the current were in the direction toward the bath, the dye was readily seen to follow in that direction, and to be ascertained in the water in the bath.

Q. How many of these experiments were performed?

A. I think there were thirty-nine, altogether.

Q. Can you describe the method by which the experiments were performed?

A. Yes, the inspector was asked to go to a designated sewer outlet and place a certain quantity of dye in the sewer and then to follow the dye in the water from the shore, to note the time at which the dye was introduced into the water, the time it appeared from the sewer outlet, the direction of the wind, the direction of the current, the time of flood or ebb tide, the length of time it took for the dye to reach the bath or the neighborhood of the bath. When it first appeared within the bath and also to note the conditions within the bath at the time, and the duration of time it took for the dye to reach the bath from the sewer outlet.

Q. And based upon these experiments, was your conclusion that it made little difference whether the 500 foot limit was reached, or a greater distance?

A. Yes, it made practically no difference. Some of the baths were contaminated at a distance considerably over 500 feet. The dye readily found its way to the baths.

Q. Where were these experiments performed, in what rivers?

A. In the Hudson and East Rivers.

Q. Can you summarize the result of those experiments, Doctor?

A. Yes, the experiments have been placed in the form of a
1730 table.

(Witness produces table covering three pages.)

A. (Continuing:) The table is in these three pages.
Q. You have prepared tables you say on these experiments?
A. Yes.
Q. And these are the experiments on the pollution of water in floating bathing establishments?
A. Yes, three tables. One in the Hudson River, one from the baths of Brooklyn in the East River and one for the baths of Manhattan in the East River.
Q. In the column headed "Inspection of Water within the Bathing Establishments" I see certain signs or marks, what do those signify?
A. The + sign means, according to the column in which it is situated, either feces, sewage, or experimental dye was present. The O means that it was not present, and the absence of either O or + means that no definite note was made of the per cent. of feces or sewage.
Q. Who prepared these tables?
A. I did.
Q. From the data that you have just described?
A. Yes.
Q. From the experimental work?
A. Yes.
Q. Will you read those tables which you have just described and which you stated you prepared relative to experiments on the pollution of water in floating bathing establishments in Manhattan on the Hudson River and Brooklyn and Manhattan on the East River.

Mr. Riker: I object on the ground that it is immaterial and irrelevant.
The Commissioner: Note the objection.

A. The tables are as follows:

No.	Date	Observers.	Situation of bath or beach.	Nearest sewer outlet.	Manhattan. Sewer in which dye was placed.	East River. Direction of current.	East River. Direction of bath from sewer.	Inspection of water within the bathing establishments. Time.	Feces.	Sewage.	Exp. dye.
13	Aug. 28, 1909.	P. B. P....	Pier 33, bet. Pike & Rutgers...	Rutgers St. Jefferson St.	..... Jefferson St.	South	South	11:40	..	..	0
14	Aug. 28, 1909.	P. B. P....	Pier 33, bet. Pike & Rutgers...	Jefferson St. Rutgers St.	..... Rutgers St.	South	South	11:55	+	+	+
15	Aug. 28, 1909.	R. N. H...	Egan's Bath*.....	Jackson St. Corlears St.	..... Corlears St.	Southwest..	Southwest.	10:52	+	+	0**
16	Aug. 31, 1909.	P. B. P....	Egan's Bath*.....	Jackson St. Corlears St.	..... Corlears St.	Southwest..	Southwest.	11:15	..	..	0**
17	Aug. 31, 1909.	P. B. P....	Adjacent free Floating bath	Jackson St. East 14th St.	..... Corlears St.	Southwest..	Southwest.	11:15	+	+	0**
18	Sept. 1, 1909.	F. H. S...	Ft. East 3th St...	East 3rd St. East 14th St.	..... East 14th St.....	South	South	12:20	..	..	0**
19	Sept. 14, 1909.	F. H. S...	Ft. East 3th St...	East 3rd St. East 14th St.	..... East 14th St.....	South	South	2:13	..	..	0
20	Sept. 14, 1909.	F. H. S...	Ft. East 3th St...	East 3rd St. East 3rd St.	..... East 3rd St.....	North	North	4:45	..	..	0
21	Aug. 31, 1909.	R. N. H...	East 90th Street Bath	East — St. East 93th St.	.....East 93th St.....	South	North	1:30	..	..	0
22	Sept. 9, 1909.	G. H. S...	East 90th Street Bath	East — St. East 93th St.	..... East 93th St.....	North	North	3:55	+‡	+	+

* Private.
** Color about bath, but did not enter it.
‡ Possibly from bath privy. G. H. S.

Brooklyn.

No.	Date.	Observers.	Situation of bath or beach.	Nearest sewer outlet.	Sewer in which dye was placed.	Direction of current.	Direction of bath from sewer.	Inspection of water within the bathing establishments.			
								Time.	Feces.	Sewage.	Exp. dye.
23	Aug. 27, 1909.	P. B. P....	58th Street	64th Street. 49th Street	64th Street	North	North	2 P. M.	..	..	0*
24	Aug. 27, 1909.	P. B. P....	58th Street	64th Street. 49th Street	49th Street	South	South	11 A. M.	..	..	0
25	Aug. 27, 1909.	P. B. P....	Ft. of Dock St....	Main Street. Fulton Street	Main Street	South	South	10:30	..	..	+
26	Aug. 31, 1909.	P. B. P....	Ft. of Dock St....	Main Street. Fulton Street	Fulton Street	North	North	4:40	+	+	+
27	Aug. 12, 1909.	J. P. F....	Dock Street	Main Street. Fulton Street	Fulton Street	South	South	1 P. M.	‡?	?	?
28	Aug. 28, 1909.	J. P. F....	Metropolitan, Ft. No. 1 Str.....	Metropolitan Av...	Metropolitan Av....	South	South	12:21	..	..	0
29	Aug. 31, 1909.	J. P. F....	Noble St. Bath...	Huron Street	Huron Street	South	South	3:45	..	..	0
30	Sept. 2, 1909..	J. P. F....	Noble St. Bath...	Huron Street	Huron Street	North	North	11 A. M.	..	..	..*
31	Aug. 12, 1909.	J. P. F....	Crescent Athletic Club	79th Street	79th Street	South	South	10:39	Water off Club pier contained feces, sewage, exp. dye.		
32	Aug. 12, 1909.	J. P. F....	58th Street	64th Street. 72nd Street	64th Street	South 12:58 North 1:35	North	....	..	..	0*

* Color about bath, but did not enter it.

‡ Color removed. Water at site of bath contained fecal matter, sewage, and experimental dye.

Manhattan: Hudson River.

No.	Date.	Observers.	Situation of bath or beach.	Nearest sewer outlet.	Sewer in which dye was placed.	Direction of current.	Direction of bath from sewer.	Time.	Inspection of water within the bathing establishments. Feces.	Sewage.	Exp. dye.
1	Sept. 15, 1909.	G. H. S....	Battery	Morris Street. Broad Street ..... Broad Street.	Broad Street	(Slow) South	West and a little South	11:45	0	0	0
2	Sept. 13, 1909.	G. H. S....	Battery	Morris Street .... West 50 Street.	Morris Street	South	South	3:15	..	..	0
3	Aug. 30, 1909.	P. B. P....	West 51 Street...	West 54 Street... West 50 Street.	West 50 Street...	North	North	4:50	..	..	+
4	Aug. 31, 1909.	R. N. H...	West 51 Street...	West 54 Street... West 50 Street.	West 54 Street...	South	South	4:22	..	..	0
5	Sept. 2, 1909..	R. N. H...	West 51 Street...	West 54 Street... West 50 Street.	West 50 Street...	North	North	9:18	..	..	0
6	Sept. 7, 1909..	G. H. S....	West 51 Street...	West 54 Street... West 80 Street.	West 50 Street...	North	North	11:54	0	+	+
7	Sept. 4, 1909..	G. H. S....	West 83 Street..	West — Street... West 80 Street.	West 80 Street...	North	North	11:24	..	..	0
8	Sept. 7, 1909..	G. H. S....	West 83 Street...	West — Street... West 80 Street.	West 80 Street...	North	North	10:45	0	+	+
9	Sept. 30, 1909.	P. B. P....	West 83 Street...	West — Street... West 108 Str.	West 80 Street...	North	North	5:50	..	..	++
10	Sept. 9, 1909..	G. H. S....	West 97 Street...	West — Street.... West — Street.	West 138 Str.....	South	South	11:23	..	..	0*
11	Aug. 31, 1909.	D. M. Jr..	West 137 Street..	West 138 Str..... West 158 Str.	West 138 Str.....	South	South	11:35	..	..	..
12	Aug. 31, 1909.	R. N. H...	*West 155 Str.... 155 Street	West — Street... West 158 Str.	West 158 Str.....	South	South	12:35	..	..	+
12	Aug. 31, 1909.	R. N. H...	Bathing Beach	West — Street....	West 158 Str.....	South	South	12:35	..	..	+

* Private.

1734 Q. In your opinion is it feasible to locate a bath in a position adjacent to the shores of Manhattan or Brooklyn where bathing would be safe?

A. No, I do not think it is possible at the present time.

Q. What do you regard are the dangers of the bathing in our waters near Manhattan and Brooklyn, in our harbor waters?

A. The danger of typhoid fever, diarrhœal diseases, purulent diseases of the eye.

Q. You said earlier in your testimony that typhoid was endemic in thic City of New York. Is it your opinion that our harbor waters contain bacillus typhosus throughout the year, throughout the bathing season?

A. I think they do during the summer and autumn.

Q. How would infection take place under such conditions to one bathing in those waters?

A. To an individual taking but one bath, the danger would be comparatively slight, but to one going in bathing as so many of them do, day after day, and taking the water in their mouths and swallowing it, I think the danger is marked.

Q. This danger to the eyes?

A. Not from typhoid bacilli.

Q. I mean from the waters?

A. Yes.

Q. Are inflammatory conditions of the eye often noted in those that have been using the floating baths?

A. They are noted.

Q. What character of eye troubles?

A. Usually in the nature of conjunctivitis.

Q. Is there any popular name for that?

A. Pink eye.

Q. Has that anything in common with the redness of the eyes which so frequently follows bathing in salt water?

A. One is purely a congestion of the eye and the other is an inflammation caused by a micro organism.

Q. In addition to the law, that you have described, Doctor, has the Department of Health in this City taken any further steps tending to discourage bathing in the Harbor waters?

A. Yes, in the year—I do not know whether it was last year or the year before—they did not approve of a number of the sites allotted by the Dock Department.

1735 Q. And in what other way have they tried to encourage other forms of bathing?

A. The Department of Public Works has built a largely increased number of interior baths, and a number of them have had swimming pools built with them.

Q. Are there many of these interior baths?

A. Yes, there are a large number in Manhattan and Brooklyn. I cannot remember the definite number of them. There are eleven baths in Manhattan and eight in Brooklyn and one in the Bronx maintained by the Department of Public Works. Three in Manhattan, two in Brooklyn, one in Queens, maintained by the Department

of Parks. Ten in Manhattan, ten in Brooklyn, two in the Bronx and one in Queens, maintained by the Department of Education.

Q. As the result of your investigation of this matter relating to free floating baths, do you regard these public baths as a source of danger?

Mr. Riker: Which do you refer to?

The Witness: Free floating baths. Yes, I believe that the use of the free floating baths, as they have been maintained by the City of New York, to be a constant danger.

Q. Did the Metropolitan Sewerage Commission make any recommendations relative to these free floating baths on the line of their dangerous character?

A. Yes, the commission in its report to the Mayor under date of April 30th, 1910, page 47, states that the commission recommends that great care be exercised in the location of public bathing establishments to avoid unsafe localities, and that the free floating bathing establishments around the water front be gradually abolished, properly planned interior bathing establishments supplied with pure water being substituted therefor.

Q. Does much of this sewage matter float on the surface of the water?

A. Yes, that can be seen by anybody on the ferries, from the ferry boats.

Q. Can flies transmit infectious diseases that may be contained in any of this sewage, if the flies come in contact with the sewage and with a human being?

A. Yes, that is a recognized medical fact that flies act as
1736 carriers of disease.

Q. Would odors along the water front from sewage affect the health of a community?

A. In a small degree. They are unpleasant and militate against one's efficiency, on account of their unpleasantness.

Mr. O'Sullivan: I think that is all.

Cross-examination by Mr. Riker:

Q. Doctor, do these odors have any more injurious effect than a great many other urban conditions such as noise and dust?

A. It is pretty hard to compare the total value of any of those things.

Q. They are in the same class, are they not?

A. Yes, they are similar conditions.

Q. Do you concur in the recommendation that the Metropolitan Sewerage Commission made to substitute interior baths for salt water baths?

A. Yes.

Q. These interior baths contain swimming pools?

A. A few of them do.

Q. Do you think the swimming pool used indiscriminately by the inhabitants of a city like this is a promoter of public health?

A. I do.

Q. Is it not frequently a fact that they are the source of epidemics of communicable diseases?

A. No, I believe not.

Q. It they are used by people that have contagious diseases, are not they liable to communicate them to others who have not those communicable diseases?

A. Not in the way the ones are maintained here.

Q. That is upon the supposition that they are properly and perfectly maintained, you are basing your testimony on that?

A. I would not say perfectly.

Q. Substantially perfect, is that what you mean?

A. Yes, with the idea that they are maintained in the proper manner.

Q. Have you ever seen in actual practice any such conditions maintained in a political institution like a public sea bath?

A. Yes.

Q. For how long?

A. I have seen it on occasions when I inspected the baths.

Q. Do not you know that swimming pools of the character you are describing have been in a great many instances con-
1737 demned as a source of communicable diseases?

A. I do not.

Q. Do not you know of any such instances?

A. Not in New York.

Q. Have you heard of them in some other places?

A. I do not think so.

Q. How many cases of pink eye have you been able to trace to the bathing in the waters of New York Bay as the cause?

A. Not any.

Q. How do you know that any have been caused in that way?

A. From hearing of cases from other doctors.

Q. They have given you their opinion that that was the cause, that is all, isn't it?

A. With the evidence that the patient had been in the bath, the free floating bath.

Q. And all other causes were excluded?

A. All the other commoner causes, yes.

Q. When you testified to the instructions that were given by your commission as to the making of these dye experiments or the effect of sewage on the water in swimming baths, did you observe personally whether they were carried out?

A. In one instance, yes.

Q. Only one?

A. I think that was the only one that I saw personally.

Q. You devised those instructions, I suppose, to the best of your ability to carry out what you wanted done?

A. Yes.

Q. Assuming that the percentage of deaths from typhoid fever in the City of Pittsburgh in 1907 to have been 130.8 as shown by your table, can you state what the cause of that high percentage was?

A. No, that would be impossible.
Q. Do you think it is from bathing in any waters?
A. It is very hard to say whether that was an epidemic or what the cause was.
Q. You do not know of your own knowledge what the cause was?
A. No.
Q. You do not know of your own knowledge or from any of these reports, as to whether there was an epidemic?
A. In that particular year?
Q. Yes.
A. No.
Q. And you have no knowledge of your own either by personal observation or by reference to authorities, as to what the
1738 probable cause was of that large percentage of that city in that year?
A. No, I could not say that.
Q. Do you know whether it was due to eating shell fish taken in the rivers about?
A. No, I never made an investigation of Pittsburg in that year.
Q. Or whether it was from fish taken in the vicinity of Pittsburg?
A. I do not know anything about it.
Q. Or fish taken from New York Harbor?
A. I do not know anything about it.
Q. Or shell fish taken from New York harbor?
A. I do not know anything about that.
Q. Then you have no way of comparing the effect of conditions in New York City and those in Pittsburg in the same year?
A. No. It would not be possible to compare them very well.
Q. Assuming that the percentage in New York City at that time from that cause of death was 17.5, do you attribute that to the bathing in New York Harbor?
A. I think a small part of it may be due to that.
Q. What part?
A. A fractional part.
Q. What fraction?
A. You could not say definitely.
Q. You are simply basing that belief, are you not, upon the fact that sewage has been discharged into New York Bay?
A. Yes.
Q. That is all?
A. You could not state that typhoid was caused by taking milk or water or from eating food, raw food, or cooked food, or from eating shell fish, but we know that all those things are causes. Just how much one exists to a greater extent than the other, has not been proven as yet. Certain epidemics can be traced of course, to certain definite articles of food or water supply.
Q. Now, take the matter of shell fish consumption, shell fish in the year 1907. Have you had any data before you, either official or collected by yourself, which would enable you to determine, what, if any part of the death rate from typhoid fever was due to the using of shell fish taken in New York Harbor in that year?

A. I could not tell that any more than anybody else could, whether it was milk or water or what it was.

1739 Q. It is a sort of a priori conclusion of yours?

A. Yes, we know there are a number of conditions that cause typhoid fever, that is one of them.

Q. Is it not a fact that the large rate of typhoid infection in American cities is due to the pollution of the drinking water?

A. I do not think so.

Q. What is it due to in your opinion?

A. I think a large amount of it is due to infected milk, and the other causes I have mentioned. Those rates vary a great deal in different cities and in different years. It would be impossible to give any definite figures for those.

Q. You would not even make a guess, would you, as to any particular percentage of the result that came from the use of shell fish taken from New York Harbor in any particular year in New York City?

A. I would not guess on that.

Q. Nor from bathing?

A. I would just be willing to say a small fraction for both.

Q. On that basis, on the assumption as given, the presence of typhoid?

A. If typhoid bacilli were present, the chances are, if they get inside you, they will do some harm.

Q. There are quite a number of ifs in the way?

A. About 4 or 5. I do not wany to try it myself.

Q. You mean by that that you would not care to bathe in the waters of New York Bay?

A. Not if I could help it, unless somebody chucked me over.

Q. Or any part of it?

A. I would not mind bathing in the Lower Bay, beyond Coney Island or Rockaway.

Q. Would you mind bathing in the Channel?

A. You mean Ambrose Channel, below the Narrows?

Q. No, the Channel outside of New York City?

A. Not unless you chucked me in, I would not want to.

Q. Why?

A. I think it is dirty, too full of bacteria, too full of sewage.

Q. What percentage of bacteria in sewage do you think constitutes a danger to bathers in salt water?

A. I would not want to make any definite statement on that.

1740 Q. Do you know anything about it, as a matter of fact, what percentage does constitute danger?

A. Yes.

Q. What percentage?

A. Any percentage.

Q. So that any infection from any source, in your judgment, renders the water unfit for use as bathing water?

A. I think so.

Q. And is the same true with reference to shell fish taken from

the water, that any pollution of the water renders the shell fish dangerous?

A. I think so.

Q. So that in your opinion, shell fish taken from New York Harbor are now and have been for several years past dangerous to consume?

A. I think so.

Q. And while you might recognize degrees of danger, if there is any danger, as a physician, you would recommend letting them alone absolutely?

A. If they came from New York Harbor, yes.

Q. Do you know how long sewage has been discharged into the waters of New York Bay?

A. I do not.

Q. A good many years within your own recollection, I suppose?

A. Ever since I can remember.

Q. And shell fish all that time have been dangerous to eat, if taken from New York Bay?

A. I think so.

Q. Unfit for food?

A. I think so.

Q. From a medical point of view?

A. Yes.

Q. Is that true of other fish taken from the waters of New York Harbor?

A. Any other fish that is eaten in raw state, clams, mussels.

Q. These bathing places that you have been testifying to, the floating baths, what is the extreme distance from a direct source of sewage pollution of any one of them under your observation?

A. I cannot remember without referring to that table.

Q. They are located along the shore front of New York City or Brooklyn, are they not?

A. Yes.

Q. And not more than 500 feet from the pier line?

A. They are closer than that to the pier line.

1741 Q. And sewers that discharge, for the most part, that you have observed, discharge sewage directly at the surface of the water, do they not?

A. Some do and some just below the surface of the water, making the opening at low tide visible.

Q. So far as you know these baths are within a comparatively short distance of such sewers?

A. I think some of them were over 1,000 feet. I do not remember exactly.

Q. I am just testing your memory in regard to that?

A. Some of them were over 1,000 feet.

Q. Is not that a very large distance from the mouth of an open sewer?

A. It is one fifth of a mile.

Q. And along the shore, further down or up the water front, they were not directly out in the stream?

A. No, along the edge of the pier line.

Q. And the discharge from the sewer being discharged even at high or low tide at the surface of the water, was, as you observed it, was carried down along the shore front?

A. Yes, down or up.

Q. So it was not a question of the sewage being carried out into the stream for a considerable distance, but merely being carried down the stream along the water front?

A. Down or up the stream.

Q. You have not got a tabulation of the deaths from typhoid in the City of Newark, have you, on your list here?

A. I think it is.

Q. In the table you have been testifying to, you have not included that?

A. I think it is; I do not remember definitely.

Q. Turning your attention to the table of the number of deaths with an estimated number of the cases of the contagious or communicable diseases in counties adjacent to the Metropolitan District in 1907, and assuming that the number of deaths from typhoid fever in 1907 in Essex County was 86, have you determined what percentage that was, in any way?

A. That is determined by taking the mortality.

Q. I asked you whether you had determined it?

A. Yes, sir.

1742 Q. Have you got it here?

A. It is given at the bottom as a foot note in that table.

Q. Will you point it out to me?

(Witness examines table)

A. The percentage of mortality, number of cases in New Jersey, 2925. That is taking the number of cases in New Jersey as 171. If the mortality in New Jersey was the same as it was in New York, there would have been that many deaths from that many cases. That is upon the assumption which I think fair, that the mortality for that year was the same in New Jersey as in New York. Of course, the New Jersey Reports are not as complete as the New York Reports, and do not give the number of cases reported.

Q. Have you determined what the percentage was in Essex County from deaths in 1907 from typhoid fever?

A. The reports do not give it.

Q. You do not know that at all, do you?

A. I stated that all I know is the number of deaths in Essex County, and I assume that the mortality for Essex County was the same as for New York.

Q. From every sort of disease?

A. Approximately the same.

Q. Why do you make such a violent assumption as that; have you got anything to base that on as a reasonable assumption?

A. I do not think that there is any marked difference.

Q. In 1907, you assume that the death rate from typhoid was the same as it was in New York?

A. The typhoid death rate varies very little the world over. It may vary between 3 and 4 per cent.

Q. You have given here a comparison of the deaths in 17 cities?

A. Those are not deaths, those are the rates.

Q. Per 100,000 living; have you made any calculation of that sort for Essex County, New Jersey?

A. No.

Q. For Newark?

A. No.

Q. You are not able to give that at all?

A. No.

Q. You do not know whether they were more or less than New York?

A. Not this minute, no.

1743 Q. Have you ever been in Newark?

A. Yes.

Q. Have you observed the Passaic River?

A. Yes.

Q. And its polluted condition?

A. Yes.

Q. You do not know whether that appears to have affected from an actual examination of the death rate, the rate of any particular infectious or communicable disease?

A. I have no knowledge.

Q. What is your specialty, Doctor?

A. I have not any specialty; I am a general practitioner.

Q. Have you made any special examination of the class of people who use the free public baths in New York City, with reference to age?

A. Not any special examination.

Q. Have you made any observation?

A. Yes, the published reports give the division between the sexes, the number of men that use the baths and the number of women.

Q. And the ages?

A. Except from what I have seen visiting the floating baths.

Q. What have you seen?

A. I have seen that the majority of them are young adults and older children.

Q. Have you made any examination as to whether or not there is any larger percentage of typhoid in young adults than other ages?

A. There is a larger percentage among young adults.

Q. You mean in New York?

A. All over the country.

Q. And has that any relation, in your opinion to the use of the bathing places?

A. Yes, I think the baths have a certain relation.

Q. All over the country?

A. Not all over the country, in New York City.

Q. I thought you said that the difference was observable all over the country?

A. That typhoid is more prevalent among young adults, yes.

Q. And you think that has some relation to the use of baths?
A. In New York City.
Q. Have you any comparative figures?
A. No.
Q. Is that again based on the general proposition that there are typhoid germs in the waters around New York?
1744 A. Yes.
Q. That is another a priori conclusion?
A. They are blamed for disease.

Redirect examination by Mr. O'Sullivan:

Q. Mr. Riker asked you, Doctor, if you had seen the Passaic River?
A. Yes.
Q. Did you see any one bathing in it?
A. No.
Q. So you would eliminate bathing in the Passaic River as a possible source of typhoid infection?
A. If no bathing occurs, I would. I do not think anybody would go in it.
Q. In discussing the mortality from typhoid, is there a ratio between the percentage of death and the percentage of inspection?
A. Yes.
Q. Is there such a ratio recognized?
A. Yes, the average mortality is recognized.
Q. By physicians?
A. By physicians.
Q. And having given the number of deaths, is it feasible for a physician to approximate the number of cases of inspection?
A. Yes, I think so.
Q. And is it regularly done by physicians who treat these topics in articles or books on the subject?
A. Yes.
Q. How would you prove that a given case of typhoid infection resulted from a given source of infection?
A. I only know of one instance where that was definitely proved. That was a case of a girl in the laboratory. She was a laboratory worker. She was changing the typhoid culture from one test tube to another, and she sucked up some of the material in her mouth, and was seen to do it, and was seen to swallow it, and she was examined every day thereafter by blood culture and by other tests, and it is believed that we could really definitely state just what the cause of her infection was. I do not know of any other instance.
Q. You could not prove it in any other way than by direct inoculation of that kind, accidental or designed?
A. I do not think so.
Q. There are many obscure causes, many things that act as germ carriers of typhoid?
A. Yes.
Q. And you could not positively prove it, could you?
A. Not unless you had a telescope and saw the bug on
1745 his way.

Recross-examination by Mr. Riker:

Q. That was a remarkable instance that you referred to. Had the girl been under observation for the period of incubation?
A. Yes.
Q. Before taking in this?
A. Yes, she had been under observation every day.
Q. Before taking in this infectious matter?
A. Yes.
Q. And you had excluded every other possible source?
A. Yes.
Q. How did you do that?
A. I did not do that personally. That was done by Dr. Park of the Health Department.
Q. And did she take this infectious matter intentionally?
A. Unintentionally.
Q. What is the period of typhoid incubation?
A. Averages 21 days.
Q. Where was she living?
A. In New York here.
Q. And she was under observation during the period of 21 days before taking in that?
A. Yes.
Q. So as to exclude the possibility of having taken it in, in any other way?
A. She was a worker in the laboratory.
Q. Did not she live at home?
A. Yes.
Q. Did not she consume the ordinary food of her home?
A. I presume she did.
Q. And take the ordinary drinks in her home?
A. I presume she did.
Q. How do you know the source of the typhoid was not from some other cause than the one you have stated?
A. Only on the assumption that we know where she got it.
Q. If somebody else had already given it to her, then you gave it to her the second time?
A. And if I could prove the first that might excuse me.
Q. In your profession can you say positively that any one thing is the cause of disease, without attempting to exclude all other causes?
A. No, we have to be reasonably sure and positive with various degrees of assurance.
1746 Q. So that this might be called the positive degree of sureness?
A. You can be pretty positive in a case of that kind.

Mr. Riker: That is all.
Mr. O'Sullivan: That is all, Doctor.

LAWSON PURDY a witness called on behalf of Complainants, being first duly sworn, testified as follows:

Direct examination by Mr. O'Sullivan:

Q. You are a resident of this city?
A. I am.
Q. A member of the Bar?
A. I am.
Q. Do you hold any official position?
A. I do.
Q. What is that position sir?
A. President of the Department of Taxes and Assessments in the City of New York.
Q. How long have you held that position, Commissioner Purdy?
A. 5½ years approximately.
Q. In the discharge of the functions of your official position, is it incumbent upon you to make appraisements of the realty of the City as well as of the personal property of the City?
A. It is.
Q. Do you have to take into consideration the population of the City?
A. For purposes of comparison, we always do take that into consideration.
Q. And where do you get your estimates of the population of the City?
A. From the Board of Health.
Q. What was the population of this City in 1908?
A. According to the estimate of the Department of Health on July 1st, 1908, it was 4,422,685.
Q. What was the population in 1909?
A. 4,564,792.
Q. Will you give me the population for the years 1910 and 1911 please?
A. 1910, 4,711,956; 1911, 4,983,385. I have the 1912 Board of Health estimate of the population on January 1st, 1912 at 5,076,976.

Q. What is the gross aggregate value of the real property of
1747 the City of New York for the years 1908, 1909, 1910, 1911 and 1912?

Mr. Riker: I object to this question on the ground that it is immaterial and irrelevant.
The Commissioner: Note the objection.

A. 1908 ..... $6,722,415,789.00
1909 ..... $6,807,179,704.00
1910 ..... $7,044,192,674.00
1911 ..... $7,858,840,164.00
1912 ..... $7,861,898,890.00

Q. Commissioner Purdy, will you give me the gross aggregate value for personal property during the years 1908 to 1912 inclusive?

A. 1908	$435,774,611.00
1909	$443,320,855.00
1910	$372,644,825.00
1911	$357,923,123.00
1912	$342,963,540.00

Q. Commissioner Purdy, does the assessed value of the personal property as you have just stated, equal the full value of the personal property in this city?

A. Only a small fraction of the personal property is subject to the general property tax. The figures I have given relate only to the personal property subject to the general property tax. Such personal property is again reduced by the debts of persons assessed. Important classes of personal property, while not exempt are taxable otherwise than under the General Property Tax. For example, the bank shares, which are not included in the figures I have given, aggregate about $350,000,000. The assets of trust companies, otherwise taxable, aggregate about $200,000,000. Mortgage debts, otherwise taxable, aggregate about two and one half billions.

Q. Are all of those items that you have just described as being taxed otherwise than under the General Property Tax Law, are they regarded as personal property in this State, Commissioner?

A. They are so defined by the section of the Tax Law
1748 which defines personal property.

Cross-examination by Mr. Riker:

Q. Mr. Purdy, if you recognize the mortgage indebtedness, of something over two billions as personal property, will you deduct that amount from the value of the real estate?

A. No, it is a deduction from the tax value of the personal property.

Q. If you recognize that as personalty, don't you allow the same amount from the realty upon which it is an indebtedness lien?

A. No. These mortgage debts are taxable, and they are at the same time deductible from the personal tax. The value of the realty is here.

Q. So that you get two values from the same thing, the value of the realty and the value of the mortgage indebtedness?

A. Yes.

Q. You are President of the Bureau of Taxes, you said?

A. I am.

Q. And do you know how these estimates of population are made by the Board of Health?

A. I know something of it. It is not my department, as you understand. They use the figures of school attendants and they check those figures by various other sources of information, and at intervals they correct their own figures by the census figures. If these figures are analyzed, it will appear that there is rather a striking change just after the census figures of the United States came out. At the same time the difference is not sufficient to affect estimates based for ordinary purposes, on these Health Board figures.

Q. Do you have a State census here?

A. We do. It comes half way between the United States Census and the Board of Health uses the State census to check their figures.

Q. That is a school census?

A. No. The State census is a complete census, as I recall it. The Department of Education reports the actual school attendance. Those figures are accurate, and obtainable by the Department of Health.

Q. The figures for the values of real estate, those are the valuations for purposes of taxation, are they not?

A. They are.

1749 Q. They are, I suppose, based upon some percentage of supposed market value?

A. The effort is made by the Department to assess at actual market value. Every week I have put before me all the sales of real property which took place during the preceding week in the Boroughs of Manhattan and the Bronx, with the actual considerations for such sales, when they are known, together with the assessed values and the percentages which the assessed values were of the actual considerations. I have the same figures put before me for the Borough of Brooklyn monthly and for the Boroughs of Queens and Richmond monthly. Those percentages have been running between 95 and 100 per cent. for the last year.

Q. Then your effort is to make a valuation at the market price?

A. It is. We are accorded by the State Board of Equalization a ratio for 1910 of 91 per cent. We think that some injustice is done in giving us so low a ratio, and that it will be raised for the coming year, but the difference is not very material for your purpose.

Q. So that the figures that you have given are actual market value?

A. I regard them as a good guide to the actual value of real estate in New York.

Q. For the periods that you have named?

A. Yes.

Mr. O'Sullivan: That is all.

At 1 P. M. adjourned for Noon recess until 2 P. M.

1750 CORPORATION COUNSEL'S OFFICE,
June 5th, 1912.—2 p. m.

JOHN P. FOX, a witness called on behalf of Complainants, being first duly sworn, testified as follows:

Direct examination by Mr. O'Sullivan:

Q. Mr. Fox, where did you pursue your studies?

A. At Harvard University.

Q. Did you graduate from there?

A. I graduated from there in 1894.

Q. With what degree

A. A. B.

Q. Did you pursue any technical line of study in other countries than here?

A. I have been making scientific investigations of different kinds in this country and Europe since I graduated.

Q. Take the year 1896, how were you occupied in that year?

A. The year 1896, I spent several months in Europe making investigations of technical education, among other things.

Q. In what countries?

A. In England and France.

Q. In 1896 and 1897?

A. From 1896 to 1897, I was Secretary of the Cambridge Conferences at Harvard.

Q. 1898?

A. 1898 I worked with Professor Atwater at Middletown, Connecticut, on the chemistry of food, doing some work for the Department of Agriculture. In the summer of 1898, I studied chemistry at the Harvard Summer School along the same line. In the fall of that year I made studies of technical education in America for the use of an English Association,—a work of statistical investigation.

Q. 1899 to 1902?

A. In 1899, I began meteorological investigations for the Blue Hill Observatory near Boston. That work continued until the Fall of 1902.

Q. Did you pursue a line of study or investigation in Europe in 1903?

A. In 1903 I went to Europe to make an investigation of City transit, to get light on conditions in New York, especially, and Boston as well.

Q. Did you make any report on that?

A. I made a report that summer to the Merchants Association of New York City and then continued transit investigations in New York and Boston.

1751 Q. What year?

A. That work has continued ever since, at more or less frequent intervals.

Q. In 1905, did you conduct any special line of investigations?

A. In 1905, beside the transit investigations, I made some investigations for what is called the Joint Metropolitan Committee of Boston, and made another trip to Europe for that Committee. That same summer I also made an investigation in Europe of the ventilation of subways, at the request of Dr. Soper, and in the fall I began work with Dr. Soper on the ventilation of the New York subway, which work I continued until the beginning of 1906.

Q. Now, in the years 1907 and 1908, what line of work were you engaged in?

A. In 1907, I began investigations of some of the problems of transit and the congestion of population in New York City, for the Congestion Committee and the City Club, and in the summer of 1907, I made an extended trip in Europe studying these problems. That work continued until 1908.

Q. In 1908, did you become connected with the Metropolitan Sewerage Commission of New York?

A. 1908 in May or June I began work with the Metropolitan Sewerage Commission, and continued that work until the Fall of 1908. I was then asked to go to Pittsburg to make a transit investigation for the Pittsburg Survey, and other work, and obtained leave of absence from the Metropolitan Sewerage Commission. Finding that this work required more time than expected, I resigned from the Commission.

Q. And did you return to your duties with the Metropolitan Sewerage Commission?

A. After completing the transit work about the first of May 1909, I took up work again for the Metropolitan Sewerage Commission which work continued until the end of November, 1909, when I was released by the Commission to undertake work for the City of Pittsburg as transit expert. That work for the City of Pittsburg continued until 1911.

Q. Did you have occasion during the year 1911 to make a survey of the City of Newark, New Jersey?

A. In the Fall of 1911 I made an investigation of certain conditions in Newark for a Committee, a survey, something
1752 along the line of the Pittsburg survey.

Q. How about this year 1912?

A. I have made similar surveys of two other cities since, Williamsport, Pennsylvania, and Utica, New York. These are what might be called civic surveys involving statistical work and scientific research and investigation of health and similar matters.

Q. Now, what was the character of your work for the Metropolitan Sewerage Commission during the year 1908?

A. My work in 1908 consisted in making a study of all the previous work of the Metropolitan Sewerage Commission going over all the records, investigations made up to that time, and studying what the investigations show. I also spent a great deal of time in making inspections of the sewers about New York Harbor, the shores, the sewage fields and similar matters.

Q. Did you have occasion to make any studies on statistics for the Metropolitan Sewerage Commission; describe in your own way the work that you did for the Metropolitan Sewerage Commission?

A. In 1908, beside the study already mentioned, the previous work and inspections, I did work investigating the currents about the harbor, and engaged in the float work.

Q. With whom did you work on the float observations?

A. I worked with Mr. Allen on the float work. With Mr. Allen, or under his direction. The work had a considerable variety.

Q. Did you make observations on the dispersion or the lack of dispersion of the sewage field as they were discharged into the harbor waters?

A. I made a large number of studies of that kind, studies of the discharge of sewage from different sewers along the water front at different stages of the tide and with different currents, and traced the sewage field from one of the largest sewers in New York City, to study exactly what became of the sewage.

Q. Did you make any observations on the shore as to the condition of these harbor waters?

A. I covered a long distance of the shores of the harbor of New York City to study the pollution of the shores by different
1753 sewers, not only the sewers of Manhattan, but also in Brooklyn and Richmond. I took photographs of polluting conditions and of people fishing in sewage, and similar matters.

Q. Have you got any of those photographs with you?

A. I have them here.

Q. I will not call for them just yet. Have you observed the results of the discharge of sewage into pier slips and other relatively small bodies of water, like Gowanus Canal and Newtown Creek?

A. Yes, I studied those in different parts of New York and Brooklyn, especially in the vicinity of sewers to observe the sewage and the odors especially, and made various experiments to determine the flow of the sewage.

Q. What kind of experiments?

A. The experiments consisted, a large part of them, in putting a dye into the sewers or the sewage at the outlets of the sewers.

Q. Then what did you do?

A. I observed the dispersion of this dye in the vicinity of the sewers, and made experiments particularly in regard to the pollution of bath houses by sewage, using the same dye for that purpose.

Q. What dyes were generally used?

A. The principal dye used was uranine.

Q. What color does that make?

A. That makes a very brilliant green, which is very enduring. We also used special scarlet somewhat.

Q. Did you make notes of your observations and inspections at the time or shortly after you made them?

A. I made notes of all my work from the very beginning of 1908 with diagrams as well as the notes themselves.

Q. And in addition to the photographs that you have spoken of?

A. And took photographs in addition of sewage fields and other conditions.

Q. Did you make reports of these observations and inspections to the Metropolitan Sewerage Commission?

A. Yes. I made reports from time to time, weekly reports to Mr. Allen, and also special reports to Dr. Soper.

Q. Did you make a special report during the summer of 1908 relating to those inspections to the Metropolitan Sewerage Commission?

A. Yes, I made an illustrated report of the inspection
1754 work, which is on file in the office of the Sewerage Commission.

Q. Did you ask them to produce that report?

A. I asked to have that report produced today, but—shall I explain—on calling up the office I was told that Dr. Soper declined to let any original work go out of the office, although they were requested for identification at this hearing.

Q. Mr. Fox, did you make any float experiments or observations in the Hudson River?

A. I assisted Mr. Allen in one of the first float experiments in the Hudson River.

Q. I show you some Complainants' Exhibits in this cause, and ask if you can identify any of them as your work? (Witness examines exhibits.)

A. I can identify all of these exhibits as prints from original drawings which I made of float experiments.

Q. Who did the plotting?

A. I did the plotting, and in three cases I made the original observations.

Q. Go over those one by one and identify them?

A. Complainants' Exhibit No. 32.

Q. State what you did about that?

A. I made the observations of this float experiment and plotted the results.

Complainants' Exhibit No. 33, I plotted the results of this float experiment No. 2.

Complainants' Exhibit No. 34, I plotted the results of this float experiment, No. 5.

Complainants' Exhibit No. 35, I plotted the results of this float experiment No. 6.

I plotted the results of the float experiments shown in Complainants' Exhibit Nos. 36, 37, 38, 39, 40, 41, 42, 45, 46, 53, 54, 55, 70, 72, 47, 43, 56, 71, 48, 58, 59, 49, and 50.

I also made the original observations of the float experiments shown in Complainants' Exhibit numbers 72 and 50.

Q. Do these plottings include observations of float experiments made in the East River as well as the Hudson River?

A. Yes.

1755 Q. And what other regions?

A. In the Harlem River and Newtown Creek as well as the Upper and Lower Bay.

Q. Are there any identifying marks on these charts by which you can readily recognize them as your work?

A. The charts have my initials J. P. F. on all of them, I believe.

Q. Now, in 1909, for the Metropolitan Sewerage Commission did you do any work as statistician?

A. In 1909 I was statistician and sanitary inspector to the Commission and began with a study of the population of Metropolitan New York and New Jersey for the Commission. The object was to find the existing population of the cities and towns and other divisions of the Metropolitan District, and to find the populations probable for different periods in the future, especially in 1940.

Q. Did that have any relation to the trunk sewer projected for the Passaic Valley?

A. Yes, I made studies for the present and future population of the Passaic Valley Sewerage District, as well as for other large sewerage districts of New York and New Jersey.

Q. Mr. Fox, did you participate in any of the experiments to determine the velocity of tidal currents, during the year 1909?

A. Yes, I took part in work both at Rockaway Inlet and at the proposed outlet of the Passaic Valley Sewer.

Q. Mr. Fox, I hand you Complainants' Exhibit No. 92 in this cause, and ask if there is a record in that exhibit of any of your work?

A. In Complainants' Exhibit No. 92, the records of the current observations near Robbins Reef, October 11th, 1909, appears to be a copy of the observations which I made on that day. I know this because I made from the original records a note of the date and what the work was.

Q. On your own records of the observations?

A. Yes.

Q. Are there any other of the observations relative to current velocities recorded in this exhibit in which you participated?

A. I made observations on one other day which I do not find here, October 6th, 1909.

Q. Did you participate in a number of experiments to
1756 determine the velocities of these tidal currents at different depths in the Upper Bay at Robbins Reef and Rockaway Inlet?

A. Yes, I took part in a number of them.

Q. What were the velocity experiments conducted with the aid of; what implement or instrument or device?

A. We used two cans in determining these velocities, the small can acting as a surface float, and the larger can being filled with sand, which was submerged to the desired depth. This large can presented a larger surface than the float in order that it should be carried by the deeper current, the smaller can presenting a lesser surface, so that the effect of the deep float would move the surface float, and thus indicate the position of the deep float.

Q. Does a summary of the results of these experiments, these velocity experiments that you participated in, appear in any report?

A. A summary appears in the report of the Metropolitan Sewerage Commission of New York.

Q. What date?

A. This report is dated April 30th, 1910.

Q. And the summary appears in that report?

A. It appears in that report, yes.

Q. You described the experiments conducted with coloring matters. I now ask you if you have examined the outlets of any of the sewers entering into Jamaica Bay and other regions?

A. I made a special study of the sewers of Jamaica Bay and the sewage proceeding from the sewers, making a special report on the subject.

Q. What did you use in making these experiments?

A. In studying the flow of sewage in Jamaica Bay, I used excelsior to some extent.

Q. What is excelsior?

A. We used flat packages of excelsior about 6 by 8 inches on the

surface, and about one quarter of an inch thick, the excelsior being compressed and confined between thin tissue paper.

Q. Why did you adopt that?

A. The object of the excelsior was to trace the currents of water in the Bay.

Q. Did you select that substance on account of its buoyancy?

A. Yes, on account of its buoyancy and its durability.

1757 Q. Just for the purpose of this record, Mr. Fox, I wish you would describe what you mean by that term "excelsior," what it means? As far as we know it might be a dye, it might be anything?

A. Excelsior is composed of fine wood shavings, very narrow wood shavings.

Q. Now, what did you note as to the discoloration of the water from these sewage outfalls as to its extent?

A. I found some very extensive fields of sewage in Jamaica Bay, the sewage in one case forming a field 7,000 feet long from the mouth of one sewer at the north end of the bay, ranging in width from 1,000 feet down.

Q. Did you take photographs of any of these discolorations or sewage fields?

A. Yes, I took photographs of a number of them.

Q. Have you got these photographs with you?

A. I have the films with one print of the films.

Q. Let me see the print?

(Witness produces the prints.)

Q. You took the photograph itself?

A. I took the photograph itself.

Q. Where?

A. It was taken from near the mouth of the 26th Ward sewer, which is the most serious source of pollution in Jamaica Bay.

Mr. O'Sullivan: I offer this in evidence and ask that it be marked Complainants' Exhibit No. 108.

Mr. Riker: Before it is marked, I would like to ask the witness some questions.

Cross-examination by Mr. Riker:

Q. Are you an expert photographer?

A. I am a photographer; I have been called an expert.

Q. Well, have you made photography a business?

A. I have made it part of my business.

Q. To what extent?

A. I have taken several thousand photographs in the course of my work in this country and Europe, and I made a great many photographs of sewers and sewage conditions.

Q. What kind of a lens did you use for this photograph?

A. These photographs were taken with folding pocket Kodak 1A.

1758 Q. That is the common photograph of the amateur, is it not?

A. You mean camera there, don't you?

Q. You say it is kodak No. A1, whatever it is. I seemed to recognize it as an amateur's outfit?

A. That is a camera commonly used by amateurs.

Q. Under what condition was this photograph taken, as to the atmosphere?

A. It was a warm hazy day, I believe.

Q. What is that black appearance on the right side of it due to?

A. That I think is a partial fogging of the film due to the sun striking in.

Q. It is a badly taken photograph, is it not, from your expert point of view?

A. I have been unable to determine the cause exactly of that fogging, it very seldom occurs in photographs that I take. It is probably due to having to change the films in an open boat where there was no shade from the sun.

Q. At what distance from the shore were you located when you took this photograph?

A. The map on the back I think shows the position. (Witness examines photograph.) (Answer continuing.) It was taken from a point about 1000 feet directly off the north shore of Jamaica Bay, and 500 feet east of the line coming from the mouth of the sewer.

Q. Does the mouth of the sewer show in your photograph?

A. The mouth of the sewer does not show in this photograph.

Q. Is Jamaica Bay traversed by steamship or steam vessels?

A. There are no steam vessels traversing this shallow part of Jamaica Bay.

Q. Is Jamaica Bay traversed by steam vessels?

A. Jamaica Bay is traversed by small steamers, at least from Canarsie south.

Mr. Riker: That is all.

Direct examination (resumed) by Mr. O'Sullivan:

Q. Mr. Fox, I hand you the exhibit, about to be marked Complainants' Exhibit No. 108, and I call your attention to a diagram on the back of that exhibit, and I ask you what it is?

A. This is a diagram made by me from my original diagram made on the spot of the sewage field formed by the 26th Ward Sewer in Jamaica Bay. The diagram shows the outline of
1759 the field, the relative thickness of the scum on the surface, the point at which the photograph was taken, with the direction, the point at which other photographs were taken, and also it has a copy of my notes made at the time in regard to the condition when the photograph was taken.

Q. Who did the actual drawing or draftmanship?

A. I drew the diagram, copying it from my diagram made at the time from a boat, of this sewage field.

Q. In whose handwriting is the written matter?

A. The written matter is in my own handwriting.

Mr. O'Sullivan: I ask that that diagram be included as part of Complainants' Exhibit No. 108.

Cross-examination by Mr. Riker:

Q. You do not intend to be understood as saying that that is a correct graphic representation of Jamaica Bay, do you?

A. It is a fairly accurate sketch of the shore of Jamaica Bay between Second Creek and Old Mill Creek.

Q. Drawn to scale?

A. No, it is a copy of the diagram made on the boat at the time, as I remember.

Q. Was that diagram drawn to scale?

A. The original diagram from which this was taken may be made to scale. I am not quite sure, because it seems fairly accurate.

Q. Is it any more than a memorandum of your observations in graphic form, made at the time?

A. It is a very carefully made diagram of the sewage field.

Q. You mean by that that you surveyed out the sewage field and laid it out on this sketch?

A. No, but my work required care and accuracy in making estimates and at the time that this diagram was made, I had had a year and a half experience in inspection of sewage fields.

Q. It does not represent any actual measurements made by you?

A. No measurement except by the eye.

Mr. Riker: I object to the offer on the ground that it is
1760 nothing more than a memorandum made at the time which can serve to refresh the memory, but cannot be made an exhibit.

The Commissioner: Note the objection. Received and marked Complainants' Exhibit No. 108.

Said photograph and the diagram on the back of same is marked Complainants' Exhibit No. 108.

Direct examination by Mr. O'Sullivan (resumed):

Q. In your work at Jamaica Bay, did you make observations of the odors as well as of the extent of these sewage fields?

A. I did.

Q. Did you make a written report to the Metropolitan Sewage Commission on your observations in Jamaica Bay?

A. I reported on the conditions in Jamaica Bay and on the odors from the sewage field, as well as other matters.

Q. Is that embodied in any report of theirs?

A. That is embodied in the general report on conditions in Jamaica Bay; also in the weekly reports made to Mr. Allen.

Q. In your observations in the harbor waters did you take other photographs of sewage fields, or did you take photographs in the neighborhood of sewer outfalls or bathing beaches polluted by the sewage?

A. I took a large number of photographs, of which the films

are in the possession of the Metropolitan Sewerage Commission, except those of Jamaica Bay, which I have here.

Q. Have you requested their production?

A. I have requested the production of the photographs which the Metropolitan Sewerage Commission have in their possession, but Dr. Soper told his stenographer this morning that none of my original work could go out of the office.

Q. What other photographs did you take that you have reproductions of here?

A. I have prints here of a few of the films, which the Sewerage Commission has in its office.

Q. The photographs being taken by whom?

A. Three of these were taken by myself and one was taken by Mr. Hoyt on his trip, when I was present.

Q. What does the one that Mr. Hoyt took in your presence
1761 illustrate; what does it deal with?

A. That illustrates persons fishing in sewage at the mouth of the 79th Street Sewer, Brooklyn.

Q. Did you take these other pictures?

A. I took the other pictures of which these are prints, three of them.

Q. What does this first one illustrate?

A. The first one illustrates Steins Beach, Brooklyn, which is the most important bathing beach north of Bath Beach, and which is situated between the two very large sewers, the 49th Street and the 63rd Street.

Q. Did you take that photograph?

A. I took the photograph, yes.

Mr. O'Sullivan: I offer that in evidence and ask that it be marked Complainants' Exhibit No. 109.

Cross-examination by Mr. Riker:

Q. When was this taken?

A. Would you like the exact date?

Q. Yes.

A. I think that photograph was taken on July 4th, 1908, because I took a photograph of that beach on that day, according to my original notes, which I have here.

Q. Was the beach open for bathers at that time?

A. Yes.

Q. How far is that from Robbins Reef?

A. That point, I think is about a mile and a half due east of Robbins Reef.

The Commissioner: Received and marked Complainants' Exhibit No. 109.

Marked Complainants' Exhibit No. 109.

Direct examination by Mr. O'Sullivan (resumed):

Q. I show you another one of these photographs and ask you who took that photograph?

A. I took this photograph and made the print.

Q. Where is the place that that is a photograph of?

A. It is a photograph of one of the sewers in South Brooklyn, at exactly what street I cannot say at this moment. It represents sewage flowing out on to a beach, which was largely used for bathing, the bathers being seen in the distance in the photograph.

Mr. O'Sullivan: I offer this photograph in evidence and
1762 ask that it be marked Complainants' Exhibit No. 110.

Cross-examination by Mr. Riker:

Q. Where did you say this was taken?

A. That is one of the sewers in south Brooklyn.

Q. And at what stage of the tide was this taken?

A. The tide is fairly low.

Q. Well, now, are you judging that from looking at the picture, or are you testifying from your recollection?

A. From the picture.

Q. Is that in accordance with your recollection?

A. Yes, because the sewers in South Brooklyn generally have the outlet between high and low water, so that when the outlet is exposed, you can be sure that it is near low water.

Q. Well, you say they generally have them; is that always the case?

A. That is the rule.

Q. I did not ask you that?

A. As I remember.

Q. I asked you whether that is always the case; in all cases whether that is true?

A. It is the case with all the sewers that I remember.

Q. You do not remember which sewer this is then that you have produced a photograph of?

A. I can find the original notes if you want to have me.

Q. I did not ask you that. I asked you whether you remembered whether you can now state what sewer this was a picture of?

A. I cannot state at exactly what street the sewer was from memory.

The Commissioner: Received and marked Complainants' Exhibit No. 110.

Marked Complainants' Exhibit No. 110.

Direct examination by Mr. O'Sullivan (resumed):

Q. Mr. Fox, have any of the photographs that you took of the sewage fields or sewer outfalls been reproduced in the Report of the Metropolitan Sewerage Commission, which was issued on the 30th of April 1910?

A. None of the sewer outfalls were, but three of my photographs were.

Q. On what page do those appear in that report?

A. Opposite page- 464 and 472.

1763 Q. You used the expression, Mr. Fox, "sewage field" what do you mean by that?

A. By sewage field I mean a body of sewage floating on the surface of the sea water or brackish water.

Q. Do you make any distinction between the term "sewage field" and the term "sleek"?

A. Yes, by "sewage field" I mean the field where the water is distinctly discolored by sewage and where suspended particles originating from sewers can be distinctly seen. By "sleek field" I mean the field outside of the sewage field where the surface of the water is covered with a thin film of oily or greasy substance, originating in some sewer.

Q. You stated that you made some of these float observations yourself and later plotted them. In making these observations and in the subsequent plotting, did you indicate on any of these charts the objects encountered by way of sewage, and whether or not you had identified any of these objects?

A. Yes, on one of the diagrams of the float experiments, I have indicated the places where sewage was seen from time to time.

Q. I hand you Complainants' Exhibit No. 50 and ask if there are any indications on that chart which you state you made the observations for and did the plotting of, any objects which you identified in making these float determinations.

(Witness examines the chart.)

Q. (Continuing:) Give the number and the date of the observations and the exhibit?

A. On the chart representing the path of Float No. 39, October 5th, 1908.

Q. Being Complainants' Exhibit No. 50?

A. Complainants' Exhibit No. 50, I have indicated the point at which evidence of sewage was seen.

Q. In what way have you indicated it?

A. By small dots.

Q. Appearing in what color on the chart?

A. Appearing as white on the blue print.

Q. Will you indicate some of these, their location?

A. They are indicated at the bottom of the chart, where they were seen, near the sewer outlets, 64th Street and 49th Street,

1764 Brooklyn.

Q. Following the course of the float, will you state the points that you encountered sewage areas or fields?

A. The sewage field was encountered all the way from 49th Street Brooklyn, to East 41st Street, Manhattan, the float being in a sewage field from 49th Street Brooklyn to East 41st Street Manhattan, for a period of 4½ hours.

Q. In following the ambulatory course of the float, did you recognize any matters that followed the float or passed it, or in any way took the same course?

A. I recognized floating in the sewage field at two points the entrails of some small animal, which were very easily identified, because of their peculiar appearance. These entrails were seen off Red Hook, Brooklyn and again near the Williamsburg Bridge in the East River.

Q. Did they follow approximately the course taken by the float?

A. They followed very closely the path taken by the float.

Q. And were those entrails amidst other sewage matters?

A. Yes, they were seen among floating fragments of human feces and white sewage particles.

Q. I think you stated that this sewage issued from the 49th Street sewer, is that so?

A. That is true.

Q. And you have just described the mode in which you identified that sewage later at the Williamsburg Bridge?

A. Yes.

Q. Did you conduct any observations at the mouth of the Union County Sewer at Elizabethport in 1909 of float or uranine, or excelsior, as you have described?

A. Yes, in company with Mr. Allen and Mr. Shaw, I went on a trip to study conditions at what is known as the joint outlet sewer of Essex and Union Counties, and I made the notes in the books on this trip. We used floats in these experiments and uranine.

Q. Now, Mr. Fox, from your float experiments and your studies of sewage fields, did you arrive at any conclusion relative to the dispersion of sewage or the length of time it oscillated in our waters?

A. Yes, I found that in the somewhat calm waters of
1765 Jamaica Bay a sewage field unbroken from one end to the other representing a 6 hours' flow of sewage from the 26th Ward sewer. I found again in the Upper Bay and East River evidences of sewage from 49th Street Brooklyn to East 41st Street, Manhattan. The water in Jamaica Bay was almost calm at the time that the field was observed there. The East River, on the other hand, is one of the most rapid and turbulent streams about New York City. I found, then, that sewage fields do not only exist in calm water, but also in the most rapid tidal currents around New York, for a period of a- least 4½ hours.

Q. Have you made studies of sewage fields where there are submerged outfalls, such as is contemplated for Robbins Reef?

A. Yes.

Q. Where?

A. In Boston Harbor.

Q. State what your observations were?

A. I visited the submerged outlet of the south Metropolitan Sewer of Boston at Peddocks Island, where there are two outlets submerged in 24 and 30 feet of water at low tide. I also examined all the available records of the sewage field produced by the sewer at Peddocks Island, measuring the sewage released, studying the currents, the dilutions of sewage and other aspects of the dispersion of sewage at that point.

Q. Did you make any observations or studies of the sewer outfall of Moon Island or Deer Island or at Nut Island?

A. Yes, I have made several visits to Moon Island and its sewage field, and also to Deer Island and its sewage field. Nut Island is the same as Peddocks Island, another name given to the same outlet.

Q. Will you state the result of your observations as to the area and extent and ratio of these sewage fields; the volume of sewage discharged?

A. Shall I answer that very fully?

Q. Yes.

Cross-examination by Mr. Riker:

Q. What is that book you are using?

A. This is a report on studies of the dispersion of sewage in tidal waters about New York and other cities.

1766 Q. Made by whom?

A. By myself.

Q. When?

A. Now. It has just been made.

Mr. O'Sullivan: Whose handwriting is that in?

The Witness: My own.

Q. Is any of it typewritten?

A. None of it is typewritten yet.

Q. When did you make the entries that you have just described as your report?

A. I have been working on this report since February.

Q. When were your observations made?

A. My observations have been made at different times, beginning in 1908.

Direct examination by Mr. O'Sullivan (resumed):

Q. Those obeervations in regard to Boston Harbor, when were those made?

A. The observations in regard to Boston Harbor that were made by myself have been made during the last two months, but the observations which I have studied for Boston Harbor have been made during the last 30 years.

Q. And where were the records that you consulted in comparing your observations with the prior observations made of Boston Harbor?

A. The records are in different reports, reports of the Boston Main Drainage System, of the Metropolitan Sewarge Board of Boston,—the Metropolitan Water and Sewerage Board of Boston, and by the State Board of Health of Massachusetts. I have also examined not only the reports of these bodies, but unpublished information in their possession.

Q. You mean as part of their records?

A. As part of their records, and I have also consulted with the officials of the Massachusetts State Board of Health, of the Sewer Department of the City of Boston, and of the Metropolitan Water and

Sewerage Board. I have studied these sewer outlets with officials of some of these boards on several occasions.

Q. And you made these studies, did you not, during this year?

A. During this year, yes.

Q. Now state what your observations were?

Mr. Riker: I object to his using this pamphlet that he has before him.

1767 The Commissioner: Note the objection.

Q. Describe what that is that you hold in your hand, whether it is your own manuscript report or whether it is a pamphlet as Mr. Riker has described it?

A. This is my own report written by myself from notes made from time to time, notes made by myself, from published reports and from original data found in Boston in the different offices. The work is all my own entirely.

Q. And it is still in manuscript form, is it?

A. It is still in manuscript form.

Q. In loose leaves, in your own handwriting?

A. Yes, sir.

Mr. Riker: I renew my objection to the use of this manuscript pamphlet, which the witness has in his hand, as not based on his own observations, and not being memoranda made at the time, or any other document on which the witness can either refresh his memory, or which contains evidence that is admissible in this cause.

The Commissioner: Note the objection.

Q. When did you make the entries of your observations?

A. I made the entries during my work for the Metropolitan Sewerage Commission, and at other times since.

Q. Mr. Fox, I am confining myself entirely to Boston. I am asking you about Boston. We have covered the Metropolitan Sewerage Commission. I am asking about the observation that you stated you made at Nut Island, at Deer Island, and at Moon Island?

A. I made those observations during the months of May and June.

Q. I asked you whether you made the entries, the notes of those observations?

A. I made them at the time of doing the work.

Q. At the time that you made the observations?

A. At the actual time.

Q. Then what did you do with those notes?

A. These notes I have here and I have written this report from these original notes made at the time, and made from the original data in Boston.

Q. Are you now holding in your hand the original notes

1768 made at the actual time of the observations?

A. I am.

Q. And the report that you have undertaken to consult is compiled from these notes by yourself, is that correct?

A. Yes, entirely so. They are made on the original notes.

Q. State what observations you made at Moon Island, Deer Island and Nut Island relative to sewage fields, sewage dispersion and odors?

A. I visited Moon Island on three occasions, on one occasion studying the sewage field from the shore, on the other two occasions studying the sewage fields in a boat. I found that the Moon Island sewage fields were very large in area, and had an extremely disagreeable odor. Entering one of the fields by boat, the strong odor of the sewage was noticeable as soon as the boat entered the field, the odor being strong and disagreeable, because the sewage at Moon Island is septic, being much decomposed. The sewage field on this day was very large in area, although not as large as it would be at other times, because the sewage had not all been discharged from the reservoirs at Moon Island. The appearance of the sewage field was very unpleasant to the sight as well as disagreeable from its odor. I observed that the sewage as it entered the harbor from Moon Island outlet was boiling violently on account of the submergence of the outlet. The Moon Island outlet is a partially submerged outlet, contrary to common opinion, the outlet being from 3 to 8 feet below the surface of the harbor water when the discharge begins, the center of the outlet being about 5½ feet *being* below the level of the harbor water. In spite of the submergence of the outlet and the resulting dilution of the sewage, the sewage field has this very disagreeable appearance and disagreeable odor which is very marked at the extreme edge of the field as it proceeds down the harbor I took photographs of the Moon Island field from different positions, and these photographs show how marked the field is, although on this day a strong wind was blowing, at one time as strong as 20 miles an hour.

Q. What effect would such a wind have on a sewage field?

A. It tends to make the sewage less visible by rippling the water,
and it also tends to disperse the sewage by the action of the
1769 waves in mixing the surface of the water, which is polluted
by sewage with the water immediately below the sewage.

Q. You have used the expression "boiling", effervescing, what do you mean by that?

A. The boiling up of this sewage is the appearance caused by the rushing of the sewage to the surface from a point below.

Q. To what is that due?

A. That is due partly to the velocity of the sewage in coming to the surface rapidly and forming a slight mound of water, which mound becomes lower at the sides of the boil and is also due to the fact that the sewage is coming from below.

Q. What I want to get at, Mr. Fox, is why does it come from below; why does it boil up as you have described it, or effervesce on nearing the surface?

A. Because the sewage is lighter than the sea water or brackish water into which it is discharged.

Q. What do you mean by "lighter", use some other term; has it lower specific gravity?

A. Because it has a lower specific gravity than sea water or the brackish water.

Q. You said you took photographs of this sewage field?

A. Yes, sir.
Q. Have you got those with you?
A. I have them.
Q. Mr. Fox, showing you this first photograph that you have handed me, I ask you what location is depicted there; what does it show that is of interest in this inquiry?
A. The water in the picture, up to a fraction of an inch, from the horizon line, is the sewage field from Moon Island, taken looking from the direction of Moon Island out to sea. The dark water in the background is the water in the harbor where the sewage field has not yet reached. The entire field from right to left is the sewage field. This is the advancing edge of the sewage field (indicating), the sewage not having yet become dispersed at the outer edge so as to be no longer visible. In other words, the field has not yet reached its fullest extent.
Q. Who took that photograph?
A. I took the photograph.

Mr. O'Sullivan: I offer this photograph in evidence and ask
1770 that it be marked Complainants' Exhibit No. 111.

Cross-examination by Mr. Riker:

Q. Did you take that with a kodak?
A. Yes, it was taken with the same kodak that I have used for ten years.
Q. And is it one of Eastman's No. A?
A. Yes, Eastman's Kodak 1A.
Q. When was this taken?
A. That was taken Tuesday, May 14th, 1912.
Q. At what hour?
A. That was taken at about 12 o'clock Noon.
Q. You say that this photograph indicates that the field had not reached its maximum?
A. Yes.
Q. How does it show that?
A. Because the edge of the field is distinct and there is not a gradual shading from the light color of the sewage into the darker water of the bay in the distance.
Q. From what was that photograph taken?
A. The photograph was taken from the launch of the Metropolitan Water and Sewerage Board.
Q. How high above the surface of the water was the camera?
A. At the height of my head, which was probably about 8 or 9 feet above the surface of the water.

Mr. Riker: I object to it on the ground it is incompetent and irrelevant. There is no evidence that it truly represents the subject that it purports to represent.
The Commissioner: Note the objection. Received and marked Complainants' Exhibit No. 111.
Marked Complainants' Exhibit No. 111.

Direct examination by Mr. O'Sullivan (resumed):

Q. I show you the other three photographs handed to me, and ask you to describe them?

A. The photograph I have in my hand is another view of the advancing portion of the sewage field from Moon Island taken on the same day at about the same time, looking to a point more north than the previous photograph. The lighter water which occupies most of the picture, is the sewage field, and the darker water in the background is the darker water of the Bay. I made a map at the
1771 time of the sewage field with the time of observation, as well as taking the photographs.

Mr. O'Sullivan: I offer this in evidence and ask that it be marked Complainants' Exhibit No. 112.

Cross-examination by Mr. Riker:

Q. Was the sun shining at the time when you took this photograph?

A. Yes.

Q. What is the light streak, immediately to the left, and above what appears to be the deck of the boat?

A. The light streak in the picture is all the sewage area, the boat being in the field at the time. The light line to which you perhaps refer, that is the edge of the sewage field, which shows here as a white line across the entire picture just below the darker water of the harbor.

Q. Was the sky cloudless when you took this picture?

A. Yes, the day was fair.

Q. There were no cloud shadows on the Bay at the time when you took this picture?

A. No, I saw no cloud shadows.

Q. You remember that, do you?

A. I made a note of the weather in my diary at the time.

Q. I asked you whether you remembered whether there were any cloud shadows?

A. Yes, I am positive there were no cloud shadows visible.

Q. You speak of the darker water of the Bay; will you indicate where you see the darker Bay water as distinguished from the sewage field?

A. Just about the light area and the white line, about ⅛th of an inch below the horizon line.

Q. That is out in the open, that is beyond the limits of the Bay, is it not?

A. No, that is well within the Bay; the island on the left is Long Island.

Q. Do you remember whether the waves were running high out at that point where your boat was?

A. No, the waves were moderate throughout the harbor, because the wind was blowing from the harbor out to sea.

Q. Is that looking out to sea?

A. That is looking out towards Broad Sound.
Q. Is that looking out towards the sea?
A. Not directly to sea.
Q. Is it in the direction of the sea?
1772 A. No, it is in the direction of the north shore.
Q. Is it in the direction towards which the wind was blowing?
A. It is in the direction away from which the wind was blowing.
Q. You mean the wind was blowing from that direction?
A. The wind was blowing from the direction in which the boat was going and blowing towards the direction in which the photograph was taken.

Mr. Riker: I object to the offer on the same grounds as to the last offer.
The Commissioner: Note the objection.
Received and marked Complainants' Exhibit No. 112.
Marked Complainants' Exhibit No. 112.

Direct examination by Mr. O'Sullivan (resumed):

Q. Mr. Fox, what is the next photograph?
A. The next photograph is a photograph of Moon Island taken in the opposite direction from the two previous photographs, looking over the sewage field, all the way to Moon Island. The water outside of the sewage field does not show in this photograph, because it is so far in the distance, the sewage field being continuous from this point to Moon Island in the back ground.
Q. What does that photograph show?
A. This photograph simply shows the distance through which the sewage field is extending, this being taken a distance of 1,000 feet or more from the front edge of the sewage field, the whole area practically included in the photograph, being the sewage on the surface of the Bay.
Q. Who took that photograph?
A. I took this myself.

Mr. O'Sullivan: I offer this photograph in evidence and ask that it be marked Complainants' Exhibit No. 113.

Cross-examination by Mr. Riker:

Q. When did you take this one?
A. That was taken shortly after the other two, at about noon on the same day.
Q. How high was your camera above the water when you took this one?
A. About 8 or 9 feet probably.
1773 Q. Did you say that the boat that you took it from was 1000 feet from the edge of the sewage field?
A. It was one or two thousand feet. I did not locate the point exactly.

Q. Where does the line of the sewage field show in that photograph?

A. In this photograph it does not show, because the sewage field extended to the space in the back ground.

Q. Why does it not show in the photograph?

A. The whole surface of the water here is covered with sewage.

Q. Did not you say you were within a distance of one thousand or two thousand feet from the sewage field when it was taken?

A. Yes, but this photograph was taken inside the sewage field entirely. From the edge I meant the edge of the sewage field was behind the point of observation.

Q. You were within the field?

A. I was within the field, yes.

Mr. Riker: I object to it as incompetent, irrelevant and immaterial.

The Commissioner: Note the objection. Received and marked Plaintiff's Exhibit No. 113.

Marked Complainants' Exhibit No. 113.

Adjourned to June 6th, 1912 at 10:30 A. M.

Supreme Court of the United States, October Term, 1911.

PEOPLE OF THE STATE OF NEW YORK, Complainants,
vs.
STATE OF NEW JERSEY and THE PASSAIC VALLEY SEWERAGE COMMISSION, Defendants.

1774

CORPORATION COUNSEL'S OFFICE,
NEW YORK, June 6, 1912—10:30 a. m.

Present: James D. Maher, Esq., Commissioner.

Appearances:

Dr. Wm. J. O'Sullivan, Special Counsel for the People of the State of New York, Complainants.

Adrian Riker, Esq., for the Passaic Valley Sewerage Commission, Defendants.

Met pursuant to adjournment.

JOHN P. FOX, a witness called on behalf of Complainants, recalled, for further examination, testified as follows:

Direct examination by Mr. O'Sullivan (resumed):

Q. Mr. Fox, before continuing your observations of Boston Harbor, have I elicited all the important facts that you observed as to the sewage fields in New York Harbor, in my examination of yesterday?

A. No, there are some more facts bearing on the case, which I have not yet given, that is on the New York fields.

Q. Will you give them to me now please?

A. In the course of the work for the Metropolitan Sewerage Commission of New York, I had occasion as already stated, to examine the sewage fields about New York City and those observations have been carefully considered to see what light they throw on the problem of the discharge of the Passaic Valley Sewer at Robbins Reef. There is one branch of the subject of sewage disposal, which has received very little attention up to the present, and that is the physical aspect of the dispersion of sewerage in tidal waters. We know that sewage discharged into bodies of sea water and brackish water disappears after a time, sometimes with a nuisance, and sometimes without any nuisance, but no one as yet appears able to depict exactly what will happen under given conditions. Where sew-
1775 age is discharged at the level of tidal waters, for instance, what area of surface will be covered and how long will a field of sewage last before disappearing? Again, what field will be produced by a gallon of sewage under differing conditions of wind and current and the temperature? What effect will the submergence of a sewer outlet to different depths have upon the size of the sewage field on the surface of the water and on the time for the sewage to disappear? In other words, what are the physical laws which would govern the proposed discharge of the Passaic Valley Sewage near Robbins Reef and determine the result of the discharge? What I say now will deal chiefly with the appearance of sewage on the surface of sea water and brackish water, and I will of course leave to others the discussion of the bacteriological and the chemical aspect of sewage in New York Harbor.

Before taking up the New York fields, I want to make clear the definition of certain terms which I shall use, and in order that that may be perfectly clear, I will repeat more carefully what I stated yesterday.

When sewage is discharged into tidal waters, it rises to the surface, if discharged below the surface, and in any case it spreads out into a field of greater or less extent, varying in shape and size according to the volume of the sewage, the depth of the outlet, the character of currents, if any, and the velocity of the wind. A sewage field, as I shall use this term, may be defined as an area of sewage, which has been discharged into a body or stream of water lying, on the surface of the water, extending in a practically continuous area until so dispersed or diffused, with the surrounding or underlying water, that the floating or suspended constituents of the sewage can with difficulty be detected by the eye. Sometimes the boundary of the sewage field is very distinct, sometimes indistinct. The area of a field, in the case of an indistinct boundary, depending upon the personal judgment of the observer. One of the best observers of sewage fields takes as the boundary the place where discoloration and turbidity are no longer clearly visible in the water. A sewage field often shades off gradually into
1776 the sleek field, which is an adjoining area outside of the sewage field, but lying in proximity with it, consisting of a

thin film of greasy or oily matter floating on the surface of the water, showing very slight traces of pollution below the surface, even by analytical means. Sleek also covers the sewage fields, but the term "sleek fields" will be used to apply only to fields composed wholly of sleek outside the sewage area. The study of sewage and sleek fields has been so meagre up to the present time that there are no universally accepted rules as to where the boundary should be taken. The strongest objections made by people to sewage fields are chiefly because of their appearance and odor, so that it is difficult or impossible to fix any standards for the boundaries of sewage and sleek fields based on chemical analysis for degree of dilution of the sewage. I want to define two words which will appear in what I say hereafter.

Q. Do you mean "diffusion" and "dispersion"?

A. Yes, sir. "Diffusion" applied to sewage means the intermingling of sewage with some other recipient liquid, such as land or sea water. That is, "diffusion" deals with liquids primarily. "Dispersion" means the separation of solids in sewage throughout some recipient liquid.

I am dealing in what I say now with "dispersion" and not with "diffusion."

I will now take up again what I observed in regard to sewage fields and seek fields in the waters about New York City.

The simplest form of sewage field I find occurs where a sewer discharges into a body of still water some way out from the shore, and where the outlet is practically unobstructed, as by piles or piers. Under such conditions there appears to be a tendency to form a circular field, even if the discharge of a sewer is horizontal. Such a circular field I noticed on two occasions about the mouth of the Oliver Street sewer in Manhattan which empties into the East River, on July 15th and July 21st, 1908. The Oliver Street sewer drains
to 172¾ acres of the lower east side of New York, discharg-
1777 ing into the East River just north of the Brooklyn Bridge. There are two outlets to this sewer, consisting of wooden barrel pipes about 4 feet 6 inches in diameter, carried out under each side of an old pier, built on piles, at the outer end of the sewers the bottoms of the pipes being situated slightly above the level of low water, the ends of the pipes being located about 15 feet in from the outer edge of the pier. The drainage area of the Oliver Street sewer is a densely populated area, and the volume of sewage discharged has been estimated at 947,500 gallons per day. On July 15th 1908 with slack low water in the East River a circular sewage field was found off and around the pier head at Oliver Street, the field having a diameter of about 150 feet. The sewer outlets were on the inner or shore end of the circular field, whose inner end was about 50 feet inside of the pier head, while the rest of the field extended about 100 feet out into the East River: A very brown discharge from the sewage was flowing out under the pier on this day, many fragments of human feces being seen floating on the surface, large in size as well as small, with much paper suspended below the surface of the water. The boundary of the sewage field was very distinct. Its area at the

time of observation was about 18,800 square feet or .43 of an acre. On July 21st, 1908, a somewhat similar field was found at slack high water. The shape was not quite so regular as before, being somewhat elliptical in form, about 200 feet across the longest diameter, in line with the axis of the pier and 100 feet across the shortest diameter at right angles to the pier axis, while a horn shaped projection of sewage extended out from the southern side of the field about 50 feet from the main field. The area of the whole field was estimated at 16,870 square feet or .39 of an acre. The comparatively small size of these two sewage fields was due to the fact that a small amount of sewage formed them, a flow of perhaps only 15 or 20 minutes of sewage. This matter will be discussed later at more length in regard to the size of these fields.

Perhaps I might say here that the Oliver Street sewer empties into the East River just south of a ferry and the ferry boats passing to and from their slips tend to cut off the field at times, be-
1778 cause the field is very shallow, lying on the surface of the water, so that at times of slack water, different areas of sewage fields are formed, changing from time to time. I have taken photographs of these changing sewage fields from the Brooklyn Bridge, and the negatives of these photographs are in the possession of the Metropolitan Sewerage Commission. There are also some prints which perhaps will be produced later. I have placed on this map the outlines of the different sewage fields observed at Oliver Street, this map being drawn to scale, and the field being copied with care from original notes made on the spot at the times of observations.

Q. Made by whom?

A. Made by myself.

Q. On what date?

A. On the dates of July 15th and 20th, 21st and 22nd.

Q. Is there any one else's work on that chart or map that you hold in your hand except your own?

A. Mr. Kuichling has put some work on indicating the ferry and the Brooklyn Bridge.

Q. Explanatory?

A. Simply explanatory terms.

Mr. O'Sullivan: I offer that map or chart prepared by this witness, relative to the Oliver Street sewer and sewage fields therefrom, I offer it in evidence and I ask that it be marked Complainants' Exhibit No. 114.

Cross-examination by Mr. Riker:

Q. When did you make this sketch?

A. I think you will find the date in the lower right hand corner with my initials.

Q. I might find the date, but that would not necessarily tell me when you made this sketch?

A. That is the date when I made it.

Q. Cannot you state what the date is?

A. If you will hand me the drawing.
Q. Certainly.
(Witness examines drawing.)
A. This diagram was made on March 5th, 1912, from my own notes.
Q. And when were your notes taken?
A. My notes were taken on the days on which I observed the fields, July 15th, 20th, 21st and 22nd, 1908.
1779 Q. Four years ago?
A. I have here the original notes.
Q. Four years ago?
A. Yes, sir.
Q. Is that your business, that of a draftsman?
A. Yes, sir, that was part of my business for the Metropolitan Sewerage Commission. I plotted the observations.
Q. What experience have you had in that business?
A. I studied drawing first about 20 years ago at Harvard and I have done a great deal of mechanical drawing ever since.
Q. Have you a survey from which you plotted this?
A. No, that is traced from the officials' plans of the Dock Department.
Q. Did you make the tracing?
A. I made the tracing, yes.
Q. Where did you find the official plans?
A. They were given to me by the Dock Department, and are at the office of the Metropolitan Sewerage Commission.
Q. One more of those holy records that cannot be taken away. Now, in laying out these dotted lines what did you do that from?
A. I had my original notes, which I have here (witness produces notes).
Q. Are all of those notes based upon measurements?
A. Those notes are based——
Q. Cannot you answer that question yes or no?
A. I will in a moment. Those notes consist of sketches made at the time and I also took photographs of the fields as well as making sketches.
Q. That does not answer my question. My question was were those notes based upon measurements. I should think that you could answer that yes or no?
A. Those notes were based on measurements by my eye at the time of observing the fields.
Q. Measurements by your eye; what kind of a scale or measuring instrument did you use by your eye, in connection with your eye, anything?
A. I use no instrument except a camera.
Q. This then is merely a sketch placed by you upon a tracing of what you think are official surveys of the Dock Department,
1780 indicating what you believe from your eye, was the measurements of these sewage fields, is that it?
A. It is not a sketch so much as a careful copy of my original records.

Q. You mean that your original notes contained a diagram?
A. I do.
Q. Why do not you put your original notes in evidence then?

Mr. Riker: I object to that on the ground that it appears that this is merely a copy of an original sketch and if competent at all, the original is the best evidence. It is also incompetent, irrelevant and immaterial.

Mr. O'Sullivan: I offer it in evidence as being an original drawing prepared at the time by this witness, and I ask that it be marked Complainants' Exhibit No. 114.

The Commissioner: Note the objection. Received and marked Complainants' Exhibit No. 114.

Marked Complainants' Exhibit No. 114.

Direct examination by Mr. O'Sullivan (resumed):

Q. Mr. Fox, you have just described to us the conditions of the Oliver Street sewer. Now, will you proceed with your other observations?

A. There was no opportunity around New York City, during the years 1908 and 1909 to study the behavior of sewage discharged at any considerable depth, below the surface of the water. Sewer outlets were found however, which were submerged a few feet at high water, and the discharge of sewage from such outlets was observed. The depth of submergence of the outlets was apparently not enough to cause any dispersion different from that noticed when the outlets were not submerged. Thus the circular shaped sewage field was found at Oliver Street, both when the sewer outlets were wholly above the level of the East River and when they were wholly covered at high water. Fragments of human feces were found floating in sewage discharged both above the surface level of the water and below it. The distinctness of the boundaries of sewage fields did not appear altered by any slight difference in the submergence of the outlet as found around New York City.

1781 Another place, besides Oliver Street, where a circular sewage field was found, was at the foot of West 50th Street, Manhattan, where the sewer discharges into the Hudson River under a recreation pier. This recreation pier is built on piles and is about 600 feet long and 100 feet wide, and the outlet of the sewer is about one third of the length of the pier in from the pier head. On July 25th, 1908, a brown sewage field with distinct outer boundary curved in shape was found extending out from the south side of the pier opposite the sewer outlet. The state of the tide was slack high water, but there was a slight ebb current to the south, just beginning under the south and north sides of the pier. The sewage field was semi-circular in general shape most of the time, the pier cutting off the northern half of any circle which might have been found, as was found at Oliver Street. The sewage field measured at its greatest extent on the day noted was about 100 feet across, along the southern edge of the pier, extending 75 feet out from the pier. The tendency of sewage to form circular fields was

only noticed at about the time of slack water. Wherever any considerable current existed, the sewage fields were elongated, varying in form and size, according to the direction and velocity of the current. There were not many sewers found about New York whose discharge into tidal waters formed sewage fields that could be easily traced and identified at all stages of the tidal currents. The continuity of some sewage fields was broken up by adjoining piers or other obstructions, or by bodies in the water around the piers. The nearness of sewage outlets to each other along many parts of the water front tended to cause the discharge from one sewer to unite with that from other outlets nearby, when tidal currents were in motion. Thus, sewage from the 79th Street sewer in Brooklyn, which issues from the end of a concrete outlet, well off shore, was found with the ebb current to pass southerly along the Brooklyn shores and to unite with the discharge from the 92nd Street sewer, about 40 minutes after leaving 79th Street, and after covering a distance of about 4500 feet. The sewage fields at Oliver
1782 Street Manhattan were plotted, mapped and photographed with different tidal currents. On July 22nd, 1908, at the beginning of flood current a field was found extending about 500 feet northeasterly with the current in the East River, the field being about 200 feet wide and covering an area of about 82,250 square feet, or 1.89 acres.

Q. This all came from one sewer?

A. This was all from one sewer, yes. Then a ferry boat came out in across the center of the field, and the field was contracted to a length of about 320 feet, with the same width of 200 feet, and with an area of about 51,200 square feet. On July 20th 1908, with ebb current, another field was found extending south from the sewer outlets about 600 feet, with a width of about 250 feet, and an area of about 142,000 square feet, or 3.26 acres. This field was elongated later on by the continuing ebb current until its farther and south end, and could be no longer seen from the point of observation. The sewage from the Oliver Street Sewer was not followed by a boat in the East River, as was done in the case of the 49th Street sewer in Brooklyn, as I have already explained, but the distance to which sewage might be carried from Oliver Street, if it persisted as long in the water as the sewage from the 49th Street Brooklyn sewer, can be judged from the distance to which floats were carried from the vicinity of outlets by tidal currents. The maximum distance reached by floats started by the Metropolitan Sewerage Commission in the East River near Oliver Street were, with flood current, about 11 miles north to a place near College Point, and with ebb current about 11 miles south to a place west of Norton's Point on Coney Island. If it be doubted whether sewage can be carried such long distances in the currents around New York City, the fact was demonstrated by the results of a float experiment which I conducted for the Metropolitan Sewerage Commission on October 5th, 1908, which I have already described somewhat.

Q. Was that Complainants' Exhibit No. 50 that was shown you yesterday?

A. That was the experiment, yes. In order to be sure of
1783 giving every detail of this experiment, I will go over it again in order that nothing may be omitted.

A float was started in the Upper Bay directly off the mouth of the 64th Street sewer in Brooklyn in order to ascertain, if possible, how far the sewage from the 64th Street sewer could be traced with flood current. The float was one of the socalled surface can varieties used by the Metropolitan Sewerage Commission, described and illustrated in their report of 1910 on page 184. It was followed by myself in a steam launch. The weather was clear and warm with a light north wind too light to ruffle the surface field from the 64th Street sewer near the sewer outlet, which is between two pile piers. The Metropolitan Sewerage Commission have a photograph taken of this sewage field, which I have just mentioned, looking out from the 64th Street sewer toward the Bay. The float was put into the water of the bay at the beginning of flood current, at a point about 150 feet out and west of the piers at the outlet of the 64th Street sewer at 11:35 A. M. At 12:30 P. M. it had moved northeasterly with the flood current along a path curving inshore so much that the float seemed sure to drift into the wall of piles enclosing the 57th Street Yacht Basin, so the float was picked up and quickly reset in the water about 450 feet farther out from the shore to the west, in order to be sure of clearing the yacht basin wall in moving north with the current. Except for this one time the float was not taken out of the water until the turn of the tide 6 hours after the start. The position of the float from time to time was observed with a prismatic campass or sextant, and exceptional care was taken in this case, on account of the unusual phenomena observed, that the float record is the most carefully prepared one of any of which I have knowledge done by the the Metropolitan Sewerage Commission. The float after resetting was no longer in the sewage field from the 64th Street sewer, but at about 1 P. M. after drifting slowly northeasterly, the float passed into the discharge of sewerage from the 49th Street sewer Brooklyn. The 49th Street sewer was a large one, draining an area
of about 1,515 acres and has its outlet in the extreme outer
1784 end of the pier head of the southernmost of a series of piers about 1300 feet long, which are of open pile construction, like the type in Manhattan. The discharge from the 49th Street sewer was found at different times to be very brown, and contained many fragments of human feces, both large and small in size, which floated away from the outlet in the sewage. The dry weather flow of the sewer was estimated at 7,575,000 gallons per day. As the float passed by the end of the pier, it entered the sewage discharge from the 49th Street sewer, as indicated on the exhibit. The sewage was flowing diagonally out into the flood current, which was moving north at a velocity of about one mile per hour. The sewage appeared to be floating on the surface of the entire sea level at the outlet, and to form a stratum of slight depth. I say this because there were particles suspended in the water, one inch or two below

the surface, which were moving out in the direction away from the sewer outlet more rapidly than particles suspended several inches below the surface. This is an occurrence which is quite common near the outlet of sewers to see particles near the surface moving faster than those a few inches below. As noticed at other times fragments of human feces were seen floating in the sewage from the 49th Street sewer out into the Bay, while outside of the more distinctly colored area of the sewage field, were seen small pieces of paper suspended in the water, and also white particles all of which had evidently come out of the sewer just before the flood current began. There was a strong odor coming from the sewage field and this odor from the field persisted most of the afternoon, the float being in the sewage from this 49th Street sewer until the float was removed at the change from the flood current to the ebb current at about 5:30 P. M. in the East River off East 41st Street, Manhattan. The odor from this sewage field was strong and almost nauseating, the day being warm and the weather nearly calm. As the float approached the 49th Street sewer outlet and entered the sewage field, it was about 250 feet out from the pierhead line at the sewer outlet. The sewage field had become a stream at this point about 100 feet wide, turbid,
brown in color, containing large and small fragments of
1785 human feces, together with white particles suspended in the
water and sleek on the surface. The float passed north with the sewage stream along the South Brooklyn shore about 500 feet out and west of the pierheads. It was now calmer than at the start. Fragments of feces were constantly seen floating off Red Hook, Brooklyn, at about 2:30 P. M. and the entrails of some small animal were seen floating in the sewage field near the float. These same entrails were seen again near the float at 4:10 P. M. when passing under the Williamsburg Bridge and in the East River and that identified the fragments of feces seen floating near them in the East River as coming from the same source as the feces in the water off Red Hook, namely, the 49th Street sewer. No other sewer was seen sending its discharge out into the East River, as far as the float during the entire course of the day, so that no other source can be assigned to the feces and other evidence of sewage seen constantly about the float than the 49th Street sewer. The float passed through Buttermilk Channel to the east of Governors Island and easterly to the East River, keeping on the Brooklyn side of the center of the channel. The velocity of the flood current increased, reaching its maximum velocity, between the Brooklyn and Manhattan Bridges, or a velocity of about 4 miles per hour. In spite of the high velocity of the current in the East River and the constant disturbance of the surface of the water by boats passing up and down and across the river, the evidence of sewage persisted, namely fragments of feces floating in the water and suspended particles and sleek on the surface. From East 25th Street to East 30th Street Manhattan the float was near the center of the river, and then gradually shifted over towards the Manhattan shore as it moved along while the velocity of the current grew gradually less. The float ceased its northerly movement with the flood current about 5:35 P. M. when off East

41st Street Manhattan. Fragments of human feces were seen floating in the water at 5:20 P. M. and 5:37 P. M. as indicated on the exhibit. The float was picked up at 6:02 P. M. after having been in the same vicinity of East 41st Street about half an hour,
1786 and after the lapse of about 6½ hours since the beginning of flood current off 64th Street, Brooklyn.

The observations of this October 5th, 1908, show how long and how far the floating fragments of human feces from a sewer may persist in sea or brackish water, even in a swift tidal current, stirred up by the frequent passage of boats. One might not be surprised at finding sleek carried long distance at times, and to be visible after a long period of time especially on a calm day, and in spite of passing steamers, but the finding of fragments of human feces floating 4½ hours after issuing from a sewer and after drifting through the East River, the most turbulent tidal stream about New York City, this may require further substantiation. In the first place, other drifting material was not mistaken for human feces, because I have had enough experience to distinguish human feces from other floating matter, and both feces and other drifting matter were observed floating in the water during the day, with their distinct difference, especially of form. I am aware that all the solids found in New York sewage cannot be expected to float 4½ hours in tidal currents and I have seen myself fecal matter sink in sea or brackish water near the outlet of a sewer discharging into the Harlem River at West 216th Street Manhattan, but the circumstances were different in this case, for the fragment of feces noticed at 216th Street floated ashore on the sand, and was rolled up and down the sloping sand, and over and over by small waves being communited by this friction until it was left only about one inch long and about one half inch in diameter before it sank. The outer portion of the fragment of feces, which was removed by friction may have acquired a coating of grease while floating in the sewer or evolved gases causing decomposition, either one of which kept it constantly afloat, until this outer portion was worn off by the friction on the sand. The distance covered by the float on October 5th, 1908, was 9 miles from the 64th Street sewer Brooklyn to East 41st Street Manhattan, covered in 6 hours. The distance covered by the float in sewage from 49th Street Brooklyn to
1787 41st Street Manhattan was 8.24 miles in 4 hours and 35 minutes. If the float had been started in the sewage discharge at 49th Street at the beginning of flood current instead of 64th Street, it would probably have floated much further north in the East River with the evidences of sewage. The float entered the sewage at the 49th Street sewer 1 hour and 25 minutes after the beginning of float current. During the last hour and 25 minutes in the East River it covered about 2.6 miles, so the float if started in the 49th Street sewage at the beginning of flood current might have carried 2.6 miles further north than East 41st Street Manhattan with the sewage, or a total distance of 10.84 miles in 6 hours.

The foregoing experiment was the only one which I made of

putting a float into the discharge of sewage in the Harbor and following the float until the turn of the tidal current. Observations were made, however, of the discharge from many other sewers and in several cases uranine or special scarlet, two powerful dyes were put into sewers or into sewage as it was being discharged at outlets, in order to study the dispersion of the sewage more readily. Fecal matter was found constantly floating in the waters about New York in the vicinity of sewers, and generally near the shore. Another occasion when it was found at a distance from the sewer was on October 11th, 1909, during studies of tidal currents near Robbins Reef at the proposed outlet of the Passaic Valley Sewer. Fragments of human feces were seen floating in the water off the Bay several times on that day, and the source was evidently one of the large South Brooklyn sewers, the nearest of which was at 64th Street, about 1½ miles southeast, and flood current was running and a very strong East wind blowing, the result of which two forces would tend to carry a floating object toward the northwest from the easterly direction to the point of observation. Some evidence of how long fecal matter will float is afforded by the investigations of Professor Boyce, of the River Severn in the Shrewsbury District, England, given in the Second Report of the Royal Commission on Sewage Disposal 1902, page 92. Two miles above Shrewsbury on the River Severn was the outfall of the sewer from
the County Asylum discharging solid feces into the fresh
1788 water river.

"And on some occasions" the writer says "we traced the lumps in the river as far as Shrewsbury" (page 94).

Again:

"Fecal matter is encountered collecting in recesses and bays on both banks of the river, nearly as far as Atcham (p. 95)."

This last would be about 6½ miles below the sewers of Shrewsbury. Now, while the velocity of the Shrewsbury River was found to range from 30 to 180 feet per minute, the actual movement of floating bodies was found to be much slower. This was discovered by putting corks into the river at one time and noting their positions on succeeding days. The report states that

"When thrown in at Shrewsbury no cork was seen further than four miles down on the following day" (p. 95).

Therefore it might have taken at least 12 hours for the fecal matter from the asylum to reach Shrewsbury and 36 hours for the fecal matter from Shrewsbury to reach Atcham. The most conspicuous and clearly defined sewage field about New York was the one produced by the discharge from the 26th Ward Sewer into the northwestern part of Jamaica Bay, just northeast of Canarsie. This sewer drains an area of 3,200 acres in Eastern Brooklyn and at the time of the observations in 1909 had a dry weather flow of about 15,000,000 gallons per day, as ascertained from the Bureau of Sewers in Brooklyn. The sewage passes through a disposal plant in East New York and then is discharged into Jamaica Bay by means of an open channel about 3,800 feet long. As the dis-

posal plant was designed to treat only 3,000,000 gallons a day, the sewage receives very inadequate purification, and the Chief Engineer of the Brooklyn Bureau of Sewers reported four years ago

"That the sewage flows away from the plant in fully as foul a condition as it reaches it, the only effect of the treatment it receives being that the effluent contains a quantity of lime, and putrefactive action is delayed several hours."

1789 I visited the outfall of the 26th Ward sewer first on October 5th, 1909. The discharge from the Disposal Works was found entering Jamaica Bay at the mouth of Second Creek through a wooden flume about 12 feet wide. The level of the sewage in the flume at its outer end being the same as the level of the water of the Bay outside at the times of observation. On October 5th, 1909, the ebb current was just beginning to run to the south by the mouth of the Creek at Canarsie. The weather was clear and calm. The discharge from the flume was very turbid and had an extremely disagreeable odor. The velocity in the flume was about 1 foot per second. The stream of sewage as it entered the bay from the mouth of the creek, was evidently very shallow on account of the following phenomenon observed. Some flat masses of excelsior about 5 by 7 inches in size and ¼ inch thick, wrapped in thin paper were put into the sewage at the mouth of the flume in order to study the direction and velocity of the tidal currents into which the sewage was discharged. One of these masses of excelsior was found in the creek below the flume with its paper covering gone and its flat shape changed to a cylindrical one, being about 7 inches long and 3 inches in diameter. This cylinder was almost submerged in the sewage and was rolling slowly over and over about once in every five seconds, the axis of the cylinder being at right angles to the flow of the current, while the top of the mass of excelsior rotated away from the flume. This rotation was clearly due to the more rapid movement of the surface stratum of the sewage over the water below which movement was also indicated by the more rapid movement of particles suspended near the surface of the sewage than those a few inches below the surface. The depth of the more rapid surface stratum appeared to be only an inch or two at a distance of from 5 to 75 feet from the flume. The rotation of the excelsior was continuous and small pieces of the wood fibre kept floating away from the drifting mass, being pulled

free by the faster surface stratum and then moved more

1790 rapidly along the creek toward the Bay. Particles suspended in the discharge from the flume near the surface were also seen to move towards the Bay faster than particles an inch or less below the surface. The extreme thinness of the surface stratum evidently did not continue very far from the flume on the day in question, because another mass of excelsior made into a cylinder by myself was put into the sewage in the creek 100 feet or more from the end of the flume, and no rotation could be observed. The sewage field from the 26th Ward sewer was not so clearly defined with the ebb current as with the flood current. With the ebb current on

October 5th, the field was found extending south by Canarsie 1 mile away from the flume marked by a film of scum and sleek on the surface, the field spreading out into the Bay to the east, and the ebb current carried it south. On October 7th, 1909, the vicinity was visited again to observe the conditions with flood current. The weather was clear and the wind very light. A slow current was found moving to the northeast in Jamaica Bay north of Canarsie. The sewage was found flowing from the flume out into Second Creek, the same as on October 5th. Off the mouth of the creek the water of the Bay was covered with a dark reddish scum extending to the northeast as far as the eye could see, its outer boundary being about one thousand feet from shore. This scum marked the sewage field produced by the discharge from the 26th Ward Sewer. It was unrippled by the light wind blowing, which rippled the water of the Bay outside. The scum on the surface was found thicker at first as the sewage flowed away from the flume being thickest at the outer edge of the field, about 1,300 feet out from and opposite to the flume. It got thinner again to the northeast, the farther one proceeded from the source of the sewage. Many small particles were suspended near the surface inside the area of the sewage field, especially white particles. The odor from the sewage was noticed as soon as one rowed inside the reddish field off Second Creek, the odor being strong and disagreeable. The sewage field on October 7th was found to extend about 7,000 feet northeast
from the shore at the mouth of Second Creek. This dis-
1791 tance was determined by comparing notes and sketches made at the time with scaled maps of Jamaica Bay, in the office of the Metropolitan Sewerage Commission. The sewage field filled the mouth of Second Creek and kept close to the shore line for a distance of about 2,400 feet from the creek averaging about 1,000 feet in width. Northeast of this point there was an area of clearer water along the shore extending as far as the mouth of Old Mill Creek, into which the sewage field extended in a curve, having narrowed meanwhile to a minimum width of 250 feet, and then widened again in the mouth of Old Mill Creek. The area of the second field as observed on this day was about 4,800,000 square feet or 110 acres. There is a possibility that the field may extend even further than Old Mill Creek with the flood current at times.

In giving observations of area in connection with these sewage fields around New York, I will state that the measurements were made in every case by a planimeter from scaled diagrams prepared from the original notes made at the time of the observations. Great care was taken to make the diagrams accurate and to make them correspond exactly with the conditions as observed. As the observations were made to determine the facts, and not to fit any preconceived ideas of sewage fields, the diagrams may be regarded as unprejudiced and amplified notes of the original observations.

Mr. O'Sullivan: I offer this diagram prepared by this witness as just testified to relative to sewage field in Jamaica Bay, I offer that in evidence and ask that it be marked Complainants' Exhibit No. 115.

Cross-examination by Mr. Riker:

Q. When did you make this, Mr. Fox?
A. I made that diagram in March 1912 at the office of the Metropolitan Sewerage Commission directly from the original diagram made at the time of the observations.

Mr. O'Sullivan: Which you now hold in your hand.
The Witness: Which I now hold in my hand.

Q. And your original memoranda were they the result of actual measurements?
1792 A. They were not the result of measurements with an instrument, but of measurements by the eye and assisted by photographs.

Mr. Riker: I object to the offer for the same reasons that were stated on the last offer.
The Commissioner: Note the objection. Received and marked Complainants' Exhibit No. 115.
Marked Complainants' Exhibit No. 115.

Direct examination by Mr. O'Sullivan (resumed):

Q. Does that complete your observations of sewage fields and sewer outfalls in Greater New York?
A. There is one more short description. Another sewage field was observed in Jamaica Bay, produced by the discharge of three sewers into Paerdegat Creek.
The conditions at Paerdegat Creek were observed on two days in October 1909, namely, October 8th and October 19th. I found that for quite a period before high water the current was flowing up this creek, backing up the sewage for quite a distance below the sewer outlets. The upper part of the creek under these conditions was filled with water which was whitish in color, with an odor probably due to the use of lime in the sewage from the Kings County Buildings which drain into this creek. With ebb current the whitish water from the creek was found flowing southeast in a well defined stream about 200 feet wide along by Bergen Beach at a distance of about half a mile from Perdegat Creek. In short from this sewage stream there was a patch of clear water along the beach about 100 feet wide with clear water again outside of the field.
In concluding the observations about sewage fields around New York City, the following are some calculations based upon these observations:
The best defined field around New York City as already stated, is that produced by the 26th Ward Sewer in Jamaica Bay. It was a sewage and sleek field combined with an area already given of about 4,800,000 square feet or 110 acres. The field was observed at the
1793 end of flood current. The 26th Ward sewer was discharging 15,000,000 gallons per day on October 7th, 1909, the flow of sewage being continuous from the flume of the 26th ward sewer. The relation of the size of the sewage and sleek field, to the

hourly flow can be obtained by dividing the area of the field by the average flow per hour, which at the time was 625,900 gallons per hour producing 7.68 square feet of field per gallon per hour. As to the length of time that sewage and sleek remained visible after leaving the outlet, the sleek was visible for about 6 hours, being found at the easterly end of the continuous field 6 hours after it must have left the flume of the sewer.

In taking up the field from the 49th Street sewer Brooklyn, the question is whether the field as found on October 5th, 1908 could be considered as extending continuously from the sewer outlet at 49th Street Brooklyn up the East River to 41st Street, Manhattan. As fecal matter was seen floating throughout the entire distance, and also sleek on the surface, with white suspended particles in the water also, two hours after the float left the sewer outlet, the sleek field covered clearly the entire distance.

The width of sewage fields in tidal waters around New York was found to vary considerably. The widest field was from the 26th Ward Sewer in Jamaica Bay as found on October 7th, 1909, which was about 1000 feet wide near the sewer outlet and 250 feet wide at the narrowest part. The sewage field observed on October 29th, 1909, off Bergen Beach, Jamaica Bay, was moving rapidly with the ebb current and was about 200 feet wide. The sewage field from the 64th Street sewer Brooklyn on August 12th, 1909, was about 200 feet wide, with a slow flood current. The field from the 79th Street Sewer Brooklyn, observed the same day as the last with ebb current, was only about 25 feet wide, but the discharge from this sewer was very small. A field from the Fulton Street Sewer Brooklyn on the same day as the last two was about 50 feet wide with flood current. The field from the East 14th Street sewer Manhattan on August 30th, 1909, was about 50 feet wide with ebb current.

1794 These fields all except the first, were generally observed merely near the sewer outlet and would undoubtedly be wider later on rather than narrower. It is safe then to assume that a long sewage and sleek field in the East River like the field produced by the 49th Street sewer in Brooklyn was at least 50 feet wide. The distance covered by the float in the sewage from 49th Street Brooklyn on October 5th, 1908 was 8.24 miles in 4½ hours. Assuming the field to average 50 feet in width for this distance, the area of the resulting field would be 2,180,000 square feet or 50 acres. The area of the field per gallon of hourly flow would be 2,180,000 square feet divided by 315,625, the number of gallons per hour, giving 6.58 square feet of sewage and sleek field per gallon of hourly flow.

Q. What other observations did you make in the vicinity of New York?

A. I went over all of these previous investigations to determine what bearing they would have on this case, that is, the proposed discharge of the Passaic Valley Sewer at Robbins Reef.

Q. Have you now related in full your observations made in New York Harbor waters, Mr. Fox?

A. Not all.

Q. Will you complete them please?

A. In reviewing and completing the observations made around New York City, there are three fundamental questions which should be borne in mind. First, are there any laws that will determine how large a sewer and sleek field will be produced by a known quantity of sewage discharged under different conditions of temperature, wind, current, and so forth.

Q. Did you take those factors into consideration in making your observations?

A. Yes, sir. Second, in the case of a continuous flow from a sewer outlet, will the same laws apply as in the case of an intermittent discharge of sewage as from reservoirs like those at Moon Island in Boston. Third, how long a time will sewage and sleek remain visible on the surface of sea water and brackish water under different conditions.

Q. Did you undertake to answer those problems in your observations?

1795 A. Yes, sir, in the light of the observations made both in New York and in Boston, taking up first what the observations made in New York showed——

Q. Before we get to that, Mr. Fox, I wish you would detail whatever is left of your observations in Boston, and then you can make the deductions with Mr. Riker's consent?

A. I found the locality which, as to the sewer outlets and sewage fields, the one most important was Boston. Boston, as is well known has three trunk sewers discharging into the harbor under different conditions, which throw much light on the dispersion and diffusion of sewage in tidal waters. The three sewer outlets are at Moon Island, Deer Island and Peddocks Island. The conditions surrounding the discharge of sewage into Boston Harbor have been investigated from time to time, but only a small part of the facts ascertained as to the discharge of sewage into Boston has ever been published and are available for reference. Therefore, I went to Boston to observe for myself the conditions and to gain access to all of the available records as to the discharge of sewage into Boston Harbor, and the conditions attending the discharge. The facts which I state in regard to Boston have been obtained by myself, at first hand either from actual observations on the spot or from persons interviewed, or from official data in the offices of the Metropolitan Water and Sewerage Board, the Massachusetts State Board of Health and the Sewer Department of the City of Boston. In order to have a clear and continuous account of the conditions as I found them in Boston, I will give a complete statement of what I found in regard to each outlet.

Mr. Riker: Now, this witness is evidently reading from a manuscript. I take it he is reading from his report and he has stated that it is based upon his own observations, and what other people told him and what he found in the records of certain bodies. Unless the witness can distinguish between what he observed himself I shall have to object to the further reading of this report, unless he separates what he has observed himself from the other sources on

the ground that the other sources are hearsay evidence and not admissible.

1796 The Commissioner: Note the objection.

Mr. Riker: I would like to ask the witness a few questions.

Cross-examination by Mr. Riker:

Q. Can you separate in your report, which you have before you, the sources of your information?

A. I cannot in every case, because it would overload the report too much to give each source of information. I lived in Boston myself for 35 years, and so have been familiar with many of the facts, and to state in each case, for every fact the source would double or treble the length of the report, but I can do it if it is desired.

Mr. Riker: I renew my objection to the reading of this report on the ground that it is admittedly not based entirely upon original sources, and is based in part upon hearsay.

The Commissioner: The objection will be noted.

Direct examination by Mr. O'Sullivan (resumed):

Q. Proceed Mr. Fox?

A. Yes. The first of the large sewer outlets constructed in Boston is at Moon Island. This was the outlet of the Boston Main drainage system completed in 1884. For the first 15 years after the completion, the sewage from this system was stored in reservoirs on Moon Island, with a capacity of 25 million gallons at one time, the sewage being discharged twice daily originally at a time beginning about 1 hour after high water, in order that the sewage might be carried as far as possible out of the harbor with the ebb current. The reservoir capacity was doubled in 1900 previous to which a more or less continuous discharge of sewage had been necessary during flood current, even as well as ebb current on account of insufficient room for storage. Since 1900, however, the discharge at Moon Island has been intermittent as in the first years of its use. The present practice is to begin the emptying of the reservoirs at exactly 1 hour after high water, closing the gates two hours later, which allows time both for the complete emptying of the reservoirs and for the flushing out of any sediment. The sewage discharged at Moon Island receives preliminary treatment at Cow Pasture, where it passes through

1797 screens and sedimentation sewers. The sewage is given an opportunity to sediment and all of the deposited matter is removed at Cow Pasture and placed in scows and does not enter the sewage which passes to Moon Island. Therefore the sewage discharged at Moon Island has a part of the solids removed, and such solide as remain have been broken up by the passage through the screens and the pumps.

Q. Mr. Fox can you tell us approximately the mesh of the screens the size of the mesh?

A. Not at Cow Pasture. I have not visited at Cow Pasture for a number of years and I cannot recollect now the size of the screens.

The length of time consumed by sewage in passing through the Boston Main Drainage system before it reaches the outlets at Moon Island is such as to cause considerable decomposition in the sewage and to make the odor very strong, as I spoke of it yesterday in my previous testimony. In other words, the sewage discharged at Moon Island is not fresh sewage, but has passed not only through the main drainage system, but through the works at Cow Pasture and has also been stored at Moon Island during a period of 10 hours. The volume of sewage discharged daily at Moon Island used to exceed 100 million gallons at times before the South Metropolitan Sewer relieved it somewhat. At the present time, May 1912, I learned from the Superintendent at Moon Island the discharge there is between 80 and 100 million gallons per day. The conditions surrounding the discharge at Moon Island today I found as follows:

The sewage is stored in reservoirs whose bottom at the lowest point is about 1 foot below mean high water. On May 13th, 1912 the surface of the sewage in the reservoirs I observed stood at 19.85 feet above the mean high water, according to a gauge at Moon Island, being about 11 feet deep in the reservoirs. These figures show that the sewage is discharged under quite a head. The outlet sewers from the reservoirs to the harbor are two in number, side by side, each one being 12 feet wide and 10 feet 10 inches high inside, the inverts at the bottom of these sewers at the outlet being 1 foot 6 inches above mean low water, and 5 feet above the bottom of the harbor
1798 at that point. Under the most favorable conditions, I am informed by the Superintendent at Moon Island, 1 million gallons of sewage have been discharged in one minute. The practice in discharging the sewage is to raise the outer gates of the two outlet sewers to a point only about 5 feet above the inverts of the sewers. On May 13th, 1912, I found the sea level at the beginning of discharge 1 hour after high water was 9.55 feet above mean low water, the reading being taken by myself from a gauge, making the top of the gate about 3 feet below the level of the harbor at the time, the inverts of the outlets at the bottom of these outlet sewers being about 8 feet below the level of the harbor at the time. The ebb currents near Moon Island were found by the engineers who were studying the construction of the proposed Boston Main Drainage System to vary from .39 to .74 of a mile per hour, or from .57 to 1.09 feet per second. The average flow of the whole ebb current receiving sewage I found was estimated to be 72,000 cubic feet per second, between Rainsford Island and Long Island, through which the sewage usually passes on its way down the harbor with the ebb current. The width of the Channel between Moon Island and Long Island through which the sewage usually passes is about 3,000 feet. The greatest depth at low water being 17 feet, the average range of the tide is about 10 feet. Floats started from the vicinity of Moon Island were found by the engineers to drift about 4 miles before slack low water occurred, reaching a point between Brewsters and George's Island. Returning with flood currents floats were found to travel about 2 miles towards the City and with the succeeding ebb current went to sea, not entering the harbor again. As I pointed out yesterday the

discharge of sewage at Moon Island, while it is generally regarded as a surface discharge, is not strictly so, because there is enough submergence of the outlet due to the position of the gate at the outlet sewer, to cause a mixture of the sewage with the sea water, as the sewage rises to the surface of the harbor. The considerable head of
the sewage, owing to the height of the reservoirs amounting
1799 to about 10 feet at the beginning of discharge which was the
case I found on the day when I studied the discharge, is also an important factor to be considered, the sewage having a considerable outward velocity away from the outlet as it comes to the surface of the water, boiling up as I described yesterday and spreading out in the water of the Bay on each side of the outlets. The velocity of the sewage on leaving the outlet sewers at Moon Island clearly has an effect similar to the discharge of sewage from a depth below the surface of the water, the combination of this horizontal velocity and the rising to the surface producing dispersion of the sewage, so that the Moon Island outlet should really be classed as a submerged outlet, not only on account of the submergence of the sewage as it issues from the outlet, but on account of the effect of the horizontal discharge at high velocity into the water of the harbor.

I examined very carefully in Boston as already stated all the available information in regard to the discharge of sewage at Moon Island that related to sewage fields. One of the most concise statements I found of conditions at Moon Island, and a statement which I was able to verify myself, in a number of particulars by observation, is the statement made in the report of the Metropolitan Sewerage Board of Massachusetts upon a high level gravity sewer for the relief of the Charles and Neponset River Valleys dated 1899, beginning with page 92. This report is the most authoritative report published on the subject of the discharge of sewage into Boston Harbor, giving, as it does the facts in regard to the conditions in Boston Harbor previous to its publication. I interviewed myself some of the men who performed the work described in this report, in order to verify the statement in the report, both the men in connection with the Sewer Department of the City of Boston, the Massachusetts State Board of Health, and the Metropolitan Water and Sewerage Board. I particularly would like to mention the fact that I interviewed the man who is responsible largely for the details of these investigations in
Boston just referred to, who made the actual observations in
1800 the Harbor of areas of sewage fields. On two occasions he
took me down the harbor to investigate the conditions in all three of the outlets. He took me through the works at Moon Island and other places.

Q. That gentleman, what is his name?

A. That gentleman is Mr. Frederick D. Smith, the present Chief Engineer of the Metropolitan Sewers. Quoting from this report, in order to give accurate and official statement as to the conditions at Moon Island, I will read the following statement:——

Mr. Riker: I object to the reading of the report on the ground that it is manifestly hearsay on the statement of this witness. It is

not proved in the manner in which a report should be proved, if the report is competent evidence.

The Commissioner: Note the objection.

Q. Mr. Fox, did I understand you to say that you interviewed the men who are responsible for the statements, the material statements in the report?

A. Yes.

Q. And they verified those statements—you verified them from an interview with the men who took them?

A. I did.

Q. And you are now dealing with one of them?

A. And I am now dealing with the work of a man with whom I have spent considerable time in Boston on this very matter.

Q. And you have interviewed that man whose statement you now intend to read?

A. These are not his own words probably, but they are the report of what he found out.

Q. And you verified the facts contained in those words that you are about to read?

A. Yes, I verified the facts in every way by trying to get at the original data and the original men.

Mr. Riker: I renew my objection.

The Commissioner: Note the objection.

Q. Proceed, Mr. Fox.

A. "When the reservoir (at Moon Island) is discharged on the ebb tide, the sewage spreads out in a broad field, curving around
1901 the upper end of Long Island, and extending across just into Quincy Bay. It again passes down the harbor through the channel between Long and Rainford Island-, but sometimes also passing into the channel southeast of Rainsford Island."

"The area covered by a reservoir discharge of 22 million gallons is approximately 750 acres."

"The discoloration of the field of 750 acres at times of a full discharge is plainly marked, on a comparatively calm day and is objectionable to sight over about two thirds of the area, but the offensive odors on a calm day are confined to a relatively small portion of the area. The presence of sewage is indicated at times by the presence of matters in suspension in the water for a distance of at least 1½ miles from the sewer outlet. Beyond this distance areas of sleek are sometimes visible and occasionally areas containing distinct traces of sewage are seen."

At 1 P. M. adjourned for Noon recess until 2 P. M.

CORPORATION COUNSEL'S OFFICE,
June 6th, 1912—2 p. m.

JOHN P. FOX, a witness called on behalf of Complainants, recalled for further examination, testified as follows:

Direct examination by Mr. O'Sullivan (resumed):

Q. Proceed, Mr. Fox.

A. "Observations of the rate of flow show that the sewage advances somewhat faster than the tidal flow for a few hundred feet from the outlet, owing to the impetus given by the high velocity in the outlet sewer."

"The temporary pollution of the sea water was mainly confined to the discolored area. This was usually found to have been broken up and dissipated in from two to three hours after the discharge of sewage depending largely upon the force of the waves."

1802 "The larger areas sometimes noticed because covered with a thin film of grease or socalled sleek, do not contain beneath this film enough sewage to be detected and the film itself is hardly of appreciable thickness." It has been found that the chief percentage of sewage in the Moon Island sewage field is in the upper two or three inches, and that although continuous sedimentation is believed to take place, it is done gradually in a volume of water so large that samples selected at a depth of 5 feet seldom show the presence of sewage either on inspection or analysis.

The published data is very scanty on which to base any deductions as to the forms of sewage fields from the Moon Island sewage. In the report on the high level gravity sewer, the area of the sewage field is given only for four days out of the eight for which observations are given. These four areas were 800 acres, 763 acres, 236 acres and 750 acres. These figures are evidently only for the sewage field and do not include the sleek field outside. For only two of the four days there is given the volume of sewage discharged making up the field. On September 14th, 1898, 11 million gallons were discharged beginning at high water, covering a plainly marked area of 236 acres, and reaching a distance of about 4,000 feet from the outlet before being so mixed with sea water as to be unrecognizable. The time consumed in the discharge is not stated. 236 acres is equivalent to about 10,275,000 square feet, which makes .94 square feet of sewage field per gallon discharged. Owing to the absence of any statement as to the time taken to discharge 11,000,000 gallons, it is impossible to give the square feet of sewage per gallon per hour. The length of time for the front end of the sewage field to reach the distance of 4,000 feet from the outlet, and to become unrecognizable, might be 1 hour and 50 minutes judging from the time of taking the last sample. This would imply a mean tidal current of 61-100ths feet per second or 42-100ths miles per hour. The figure of .94 square feet of sewage field for 1 gallon of sewage discharged found on September 14th, 1898, for Moon Island is lower than any other figure for a sewer outlet near the

surface, but the Moon Island figures are for sewage fields
1803 only without the sleek, and also for an intermittent discharge of sewage, and not a continuous discharge, such as is found in the other cases discussed.

On October 13th, 1898, 22 million gallons of sewage were discharged at Moon Island, beginning about 40 minutes after high water and ending within three quarters of an hour. About 750 acres were covered by the discharge. The color of the sewage was stated to have disappeared at a distance of about 10,000 feet from the outlet or two hours after the beginning of the discharge. The 750 acres appears to be the sewage field only, including no sleek, and is equivalent to about 32,700,000 square feet giving an area of 1.49 square feet per gallon of sewage discharged. It will be noticed that while the quantity of sewage discharged this day was just twice as much as on September 14th 1898, the area of the sewage field was about three times the size. This increase in the size of the sewage field at a greater rate than the increase in the flow of sewage is explained as follows:

Mr. H. W. Clark the Chemist of the Massachusetts State Board of Health in discussing this fact makes the following statements in the report on the high level sewer already referred to:

"When the amount of sewage discharged from the reservoir (at Moon Island) is only one half the usual amount the area covered is only about one third as large. Reasoning from this it seems probable, if the volume of sewage discharged at each tide should become twice as great as the volume now discharged the area covered by it might be at least 1,500 or 2,000 acres, and that, because of such a large discharge, a large area would remain covered with sewage for several hours. The area of dense pollution would also be correspondigly enlarged."

At Deer Island on the north side of Boston Harbor, sewage from the North Metropolitan District of Boston has been discharged since 1895. The discharge is continuous and not intermittent, as at Moon Island. The outlet is at the end of a 76 inch pipe, which has a vertical opening practically at the level of mean low water,
1804 situated on the west side of the South end of Deer Island Bar, about 300 feet due West of Deer Island light. The width of the main channel between the sewer outlet and the shore of Long Island due south is about 3,250 feet having a maximum depth of 75 feet at low water. The average flow of the whole ebb current in this channel was found to be 269,000 cubic feet per second. Slack water lasts about three quarters of an hour at high water at the outlet. The average range of the tide is about 10 feet. The present volume of sewage discharged is about 60 million gallons per day. The sewage discharged at Deer Island is collected from a large area north of the center of Boston, extending west to the Town of Lexington, north into the Town of Stoneham and Wakefield, and east through the Town of Winthrop. The area of the North Metropolitan District is given on the official map as 91 square miles. The sewage is all screened before discharging into the harbor at Deer Island through screens with two sets of circular bars close enough together

to catch paper and other solids, and to break up all soft solid matter, so that no large floating matter appears in the sewage field. The formation of the sewage field at Deer Island is described as follows by H. W. Clark, Chemist to the State Board of Health in his report to Wm. M. Brown, Jr. Chief Engineer of the Metropolitan Sewerage Commissioners, on the high level gravity sewer, report dated 1899, page 94.

"The general direction in which the sewage is carried after leaving this outlet is as follows:

"When the tide is ebbing the sewage runs out to sea for a large part of the time nearly in an easterly direction. When the tide is coming in the sewage current swings slowly around. This movement, however, is somewhat delayed by the fact that the sewer outlet is on the harbor side of the bar, stretching from Deer Island to Deer Island Light. As the tide enters the lower portion of the harbor and comes around the upper end of Long Island, its tendency is to keep the sewage field flowing in the direction of the lower end of Long Island, until the water has risen enough to cover the bar between Deer Island and Deer Island Light. The sewage is then carried in the direction of Governors Island."

1805 "At high water there is a sewage field lying south and west of the outfall. As the ebb current starts this field moves outward over Broad Sound and is connected with the outfall by a band of sewage varying from 50 to 250 feet in width."

With ebb current Mr. Clark states:

"The discoloration has nearly disappeared when the sewage has moved 1⅛ miles from the outlet, which takes about 1¼ hours. Beyond this distance only the sleek can be found, and this only on calm days. The area covered by the discolored field is about 350 acres during the ebb tide, but the sleek area is about 450 acres. A field of sewage collects on the west side of Deer Island spit at low tide. This field extends nearly to the Deer Island shore. The discoloration can be traced for about one and one half hours reaching a distance of about one mile, and covering an area of about 300 acres."

On calm days with flood current the sewage and sleek field combined at Deer Island is stated in the report to be about 300 acres.

The discharge from the Deer Island outlet is very brown in color, at first, due to wastes from tanneries. The color is very marked in the vicinity of the outlet, because the sewage is concentrated there at the surface of the water. The brown color changes into a turbid gray as the sewage field spreads out.

Q. Mr. Fox, did you take any photographs of the sewage fields that you have just described?

A. Yes, I took a number of photographs of the sewage fields at Deer Island from the sewer outlet to the edge of the field. The first photograph was taken at the outlet of the sewer near Deer Island light at about 12:30 P. M. on May 14th, 1912. The sky was cloudless at the time. The sewage field shows in the photograph as a light colored field near the center of the photograph, this being the sewage

field immediately above the outlet, which was submerged at the time the photograph was taken. The sewage was flowing in a narrow stream between the point of observation and the lighthouse.
1806 It was very brown in color as already described. The close proximity of the sewage to the lighthouse will be noticed.

Mr. O'Sullivan: I offer this photograph just described by this witness in evidence and ask that it be marked Complainants' Exhibit No. 116.

Mr. Riker: Same objection as to the last photograph.

The Commissioner: Note the objection. Received and marked Complainants' Exhibit No. 116.

Marked Complainants' Exhibit No. 116.

Q. Proceed, Mr. Fox?

A. The next photograph was taken on the same day, May 14th, 1912, shortly after the first photograph from a boat in the center of the sewage field from Deer Island at a point about 1,000 feet east of the lighthouse. The view is taken looking toward the northwest, Deer Island being at the right of the photograph. The sewage field in this photograph covers the entire area of the water except the dark portion of the water in the back ground, which is the clearer water along the Deer Island shore. The sewage field at this time was passing out to sea with the ebb current, while the water along the Deer Island shore was unpolluted. The lighter color of the sewage field in these photographs is due to the smoothness of the surface of the water, caused by the film of sleek on the surface, while the unpolluted water is rendered darker by being ruffled by the wind, the velocity of the wind on the day that this photograph was taken was as high as 20 miles an hour, but the sewage field was but little ruffled by the strong wind. The odor of the field was very noticeable in passing through it in the boat.

Mr. O'Sullivan: I offer this photograph just described by the witness in evidence and ask that it be marked Complainants' Exhibit No. 117.

Mr. Riker: Same objection as to the last photograph.

The Commissioner: Note the objection. Received and marked Complainants' Exhibit No. 117.

Marked Complainants' Exhibit No. 117.

Q. Proceed, Mr. Fox?

A. The next photograph was taken on May 14th, 1912, soon after 12:30 P. M. as the boat was proceeding out to sea from the
1807 lighthouse. The weather conditions were the same as the two preceding photographs. Almost the entire area of the water seen in the photograph represents the sewage field, showing here as lighter in color than the water in the distance. The dark line immediately below the horizon, a fraction of an inch in width, is the darker water beyond the advancing sewage field, the darkening being caused as before by the ruffling of the unpolluted water by the strong wind which was blowing. The edge of the sewage field from Deer Island on this day was very distinct and can be

clearly seen in this photograph. The sewage field had not reached its fullest extent when this photograph was taken, but was still advancing in an easterly direction. The sewage field soon after this photograph was taken had reached a black and red buoy in the center of Broad Sound, about a mile and a half distant from the lighthouse.

Mr. O'Sullivan: I offer the photograph just described by this witness in evidence and ask that it be marked Complainants' Exhibit No. 118.

Mr. Riker: The same objection as to the last photograph.

The Commissioner: Note the objection. Received and marked Complainants' Exhibit No. 118.

Marked Complainants' Exhibit No. 118.

Q. Proceed, Mr. Fox?

A. This photograph was taken on May 26th, 1912, at 2:45 P. M. from the deck of a harbor steamer passing Deer Island. No cloud shadows were visible at the time of taking the photographs. The photograph shows Deer Island Light at the extreme right of the picture and extending from the lighthouse to the left of the photograph is the sewage field from Deer Island with flood current. The sewage field shows as a light streak extending from the lighthouse to the left edge of the picture, in the distance, just below Deer Island. Over the light streak in the photograph, at the right hand end can be seen the darker water of the harbor just beyond the sewer outlet. The sewage as seen from the steamer was brown in color and had backed up from the outlet of the sewer directly against the lighthouse.

1808 The sewage field on this day, as on the previous day, was thus seen in close proximity to the lighthouse, on the second day being immediately under the lighthouse itself.

Mr. O'Sullivan: I offer the photograph just described by this witness here in evidence and ask that it be marked Complainants' Exhibit No. 119.

Mr. Riker: The same objection as to the last photograph.

The Commissioner: Note the objection. Received and marked Complainants' Exhibit No. 119.

Marked Complainants' Exhibit No. 119.

Q. Proceed?

A. The next photograph was taken on May 28th, 1912, at about 2 P. M. with ebb current. The point of observation was south of Deer Island Light House looking northwest across to the light towards the pumping station of the North Metropolitan District on Deer Island. Near the center of the photograph directly under the chimney of the pumping station is the sewage field over the outlet of the Deer Island Sewer. The sewage field shows in the photograph as a light area of smooth water. This smooth water extending to the right edge of the picture showing the sewage as it flowed by the lighthouse to the eastward.

The wind on this afternoon was blowing from 30 to 40 miles an

hour from the southwest. At the time I took this photograph I was accompanied on the launch of the Metropolitan Water and Sewerage Board by the Chief Engineer Mr. Frederick D. Smith, Professor George C. Whipple of Harvard University, Professor Earl B. Phelps of the Massachusetts Institute of Technology, and Mr. Desmond FitzGerald of Brookline.

Mr. O'Sullivan: I offer the photograph just described by this witness in evidence and ask that it be marked Complainants' Exhibit No. 120.

Mr. Riker: Same objection.

The Commissioner: Note the objection. Received and marked Complainants' Exhibit No. 120.

Marked Complainants' Exhibit No. 120.

1809 A. (Continuing:) The marked characteristic of this photograph is the smoothness of the sewage field in contrast with the very rough water produced by the high wind.

Only the complete data for two days' observation made in 1898 of the Deer Island Sewage fields have been published, although I have examined many other records of the sewage fields. On September 2nd, 1898, with ebb current the sewage field covered 350 acres, not including the area of sleek, as determined by H. W. Clark, Chemist of the Massachusetts State Board of Health and given in his report to Mr. Wm. M. Brown, Jr., already quoted from. The volume of sewage discharged for the day was about 40 million gallons. 350 acres is about 15,250,000 square feet. The average discharge of sewage per hour would then be 1,666,666 gallons giving an area of sewage field of 9.15 square feet per gallon per hour. The time that the sewage remains visible in the passing away from the outlet is not stated, nor the area of the sleek field. On October 24, 1898, with flood current the area of plainly marked pollution was stated by H. W. Clark in the same report to be 175 acres. Sewage was being discharged on that day at the rate of about 48 millions gallons per day. 175 acres is about 7,625,000 sq. ft. As the average hourly flow was 2 million gallons there were 3.81 square feet of sewage field per gallon of hourly flow. The exact time taken for the sewage to disappear cannot be determined from the report.

The latest sewer outlet in Boston Harbor is the submerged one of the south metropolitan system, or the high level gravity sewer situated north of Nut Island, and west of Peddocks Island, the outlet being associated with both of these names. The south metropolitan sewer has its masonry construction end at Nut Island, where there are sand catches and screens, and from which pass two lines of cast iron 60 inch pipe, pass out in the bottom of the harbor, about a mile to the north of Nut Island, where there are two vertical outlets placed about 1,500 feet apart. Only one of these outlets is in regular use, namely the easterly one. The outlets were used alternatively at first, after the sewer was built, but the sewage, when discharged from the western outlet, was found by the Metropoli-

1810 tan Sewerage Board to be carried too much into Quincy Bay. Therefore only the eastern outlet is in regular use to-day,

the western outlet being used only at occasional intervals in order to clean it out. The top of the western outlet is 30 feet below mean low water. The top of the eastern outlet is 24 feet below mean low water. The use of the south metropolitan sewer began in 1904. The volume of sewage discharged daily varies between 40,000,000 and 50,000,000 gallons per day. The sewage is screened at Nut Island through screens of vertical round bars of the same size and description as those at Deer Island. These bars catch solids the same as at Deer Island. The area of the south metropolitan district is 103 square miles, according to the official map of the Metropolitan Water and the Sewerage Board. The discharge of sewage at Peddocks Island is continuous, as at Deer Island. The average flow of the whole ebb tide between Peddocks Island and Rainsford Island is stated by Mr. William M. Brown, Jr., at that time Chief Engineer of the Metropolitan Sewerage Board, as 200,000 cubic feet per second, in his report on the high level gravity sewer, dated in 1899. The average volume of the tidal current which passes Nut Island during ebb tide is stated by Mr. Brown to be about 77,000 cubic feet per second. The average flood volume was estimated by Mr. Brown to be about the same as the volume of the ebb current into which the Moon Island sewage is discharged, namely, 72,000 cubic feet per second. Floats started under Mr. Brown's direction from points near the present outlets were found with ebb current to reach a point one or two miles outside of Boston Light or from 5 to 6 miles from the starting point, having an average velocity of about one mile per hour, or 1.47 feet per second. The floats did not return into the harbor with the flood current. A period of slack water lasting about an hour was found at high water, and the ebb currents were weak until about half an hour after the time of high water. The sewage at Peddocks Island rises to the surface of the water of the harbor causing a boiling action over an area about 50 feet in diameter. The discharge is dark in color, more than that, brown. No very large suspended matter is seen, as the sewage is all screened at Nut Island.

1811 The boiling area is smooth on the surface, breaking up the waves, even on windy days. The outlets are located in a place very much exposed, especially in directions between west and south, there being a three mile stretch of open water in this quadrant. As a result it is more difficult to trace the sewage field than at Moon Island or Deer Island. Even on a very windy day, however, the sewage fields at Peddocks Island have been followed for distances of half a mile from the outlet, if the current and the wind are moving in the same direction. The sewage, as a rule, is more dispersed than that from Moon Island and Deer Island, as the areas of the sewage field will show.

This first photograph (the witness examines photograph) was taken on May 14th, 1912, at about 11:40 A. M., at the east outlet of the south metropolitan sewer off Peddocks Island. There were no cloud shadows visible on that day. The wind was high, blowing about 20 miles an hour. Ebb current was running at the time of the observation. On this day I visited the outlet shown in the photograph with Mr. Frederick D. Smith, the chief engineer of the

metropolitan sewers of Boston. In the center of the photograph at the mark "A" extending to the right of the photograph at "B" is seen a smooth light colored area which is the sewage field directly over the east outlet of the sewer off Peddocks Island. The water in the foreground and in the background is darker than this sewage field, the area of the field being distinct at the outlet. The field between the points "A" and "B" is the area where the boiling takes place from the outlet at the bottom of the harbor at this point. The east outlet at mean low water is 24 feet below the level of the harbor. At the time this photograph was taken, the outlet was about 30 feet below the level of the harbor water. The sewage on this day, as on other days, rose directly from the sewer outlet to the surface of the harbor water, in a time estimated by Mr. Smith, the chief engineer of the metropolitan sewers, in my presence at a quarter of a minute. Mr. Smith stated he believed the sewage rose very rapidly to the surface in an almost unbroken mass, and the evidence of this was plainly visible to me at the time this photograph was taken.

1812 The sewage field on the day I visited this outlet with Mr. Smith extended about half a mile northeast from the outlet, and was distinctly visible to this distance although the wind was blowing about twenty miles an hour. The width of the field was about 1,000 feet.

Mr. O'Sullivan: I offer in evidence the photograph just described by this witness, and asked that it be marked Complainants' Exhibit No. 121.

Mr. Riker: The same objection as to the other photograph.

The Commissioner: Note the objections. Received and marked Complainant's Exhibit No. 121.

Marked Complainant's Exhibit No. 121.

Q. Proceed?

A. The next photograph was taken on May 28th, 1912, at about 3:30 P. M., when ebb current was running. It is a photograph of the sewage field at the east outlet at Peddocks Island, looking in a southeasterly direction from a point in about the center of the sewage field. The photograph was taken when the boat in which I was situated was passing through the sewage field and over the outlet. The wind on this day was blowing from 30 to 40 miles an hour, and at the time the photograph was taken the wind was especially strong, ruffling slightly even the sleek of the sewage field. In spite of the high velocity of the wind the smoothness of the sewage field is plainly shown in the photograph. The sewage field in the photograph occupies the lower edge of the picture up to a point about one quarter of an inch below the horizon. The center of the ascending column of sewage is at about point "A" to the right hand side of the photograph. The water beyond the sewage field is seen to be broken up by the waves with white caps formed by the high wind. The sewage field on this day, in spite of the wind could be traced in the direction of the ebb current for a considerable distance from the outlet.

Mr. O'Sullivan: I offer in evidence the photograph just described

by this witness and ask that it be marked Complainant's Exhibit No. 122.

Mr. Riker: The same objection as to the last photograph.

The Commissioner: Note the objection. Received and
1813 marked Complainant's Exhibit No. 122.

Marked Complainants' Exhibit No. 122.

Q. Mr. Fox, in addition to the photographs which you stated you took, and which are now marked in evidence, did you make any diagrams, charts or other outline drawings of any of the observations that you made in Boston Harbor?

A. Yes, on May 14th, 1912, when I visited the three sewage fields in Boston Harbor, with Mr. Frederick D. Smith, chief engineer of the metropolitan sewers of Boston, I made on an official map which he gave me notes and diagrams of the sewage field and other data. Mr. Smith later gave me another map of the harbor, a chart on a larger scale, on which I carefully transferred the data obtained on the spot, outlining the sewage fields, as I observed them on that day. On this second chart I have also traced the boundaries of the sewage fields as determined by the Metropolitan Sewerage Commissioners of Massachusetts in 1905. Mr. Smith kindly put at my disposal the diagrams which were made for the Board of the sewage fields at Peddocks Island as observed in 1905, and I made a careful and accurate copy of all the data on the charts in Mr. Smith's possession and also noted down all the descriptive matter on the charts. The fields, as shown on the charts, which I have here, are, so far as I could learn, all the outlines of sewage fields which are available for Peddocks Island as I was unable to learn of any other such information in Boston. On this chart the outlines of the different sewage and sleek fields are indicated by lines and the date of each field is placed alongside of each line. In the case of the fields observed in 1905 by the Metropolitan Sewerage Commissioners two sets of lines are given for each field. One the outline of the sewage field, the other the outline of the sleek field. On one or two days the sleek field, however, was not determined, and only the outline of the sewage field is given. On May 14th, 1912, when I visited these sewage fields, the boundaries indicated by the chart indicated simply the sewage fields, the sleek areas not being indicated. The areas of the
sewage and sleek fields determined in 1905 were measured
1814 by means of a planimeter, and the length and width of the fields were measured from the original charts in the possession of the Metropolitan Water and Sewerage Board of Boston. The volume of sewage discharged on each day, and other data which I shall give presently was taken from the data on the original charts in the Boston office by me. The volume of sewage discharged on May 14th, 1912, when I visited the outlet with Mr. Smith, was given to me by Mr. Smith, after he had looked the matter up from the records at Nut Island. The velocities of the tidal currents at Peddocks Island were taken from float observations made off the outlets of the south metropolitan sewer.

Mr. O'Sullivan: I offer in evidence the chart or map just de-

scribed by this witness, showing the sewage fields outlined by him thereon, and ask that it be marked Complainants' exhibit No. 123.

Cross-examination by Mr. Riker:

Q. Mr. Fox, where did you get the bases for this chart that you have offered here?

A. That is a chart given to me by the chief engineer of the Sewer Department of the Metropolitan Water and Sewerage Board, Frederick D. Smith.

Q. You have done nothing to verify it, have you?

A. No, except to look at the source of it in the corner. It is based on the chart of the Harbor and Land Commission of Massachusetts.

Q. In the way of independent verification you have done nothing?

A. No, I have done nothing besides look at the source of it.

Q. Outside of your confidence in the source you have no way of telling whether it is accurate or not?

A. No, I have not tested it in any other way.

Q. What have you put on this chart yourself?

A. I have put on that chart all of the outlines representing sewage and sleek fields around the three outlets, Moon Island, Deer Island and Peddocks Island.

Q. Now, in reference to Moon Island, where is there indicated on this offer any outlet in connection with that Island?

1815 A. The outlet is at that point just to the right of the word "outlet."

Q. Did you put that on?

A. No, that was put on.

Q. What have you put on there?

A. I have put the outlines of the field in line away from the outlet.

Q. Respecting the Moon Island indications that you say you have put on this chart, what day does the outline that you have sketched in there indicate the condition of the field for?

A. May 14th, 1912.

Q. And this outline, is that the result of a survey by you?

A. It is the result of observations made from a boat passing around the field, not what you would call a survey.

Q. Is it what you would call a survey?

A. No, simply observations from a boat.

Q. Noted at the time?

A. Noted on another map at the time and then transferred to that as accurately as possible.

Q. You say that as you went along you sketched out this field on this other map?

A. Not on that map, but on another map.

Q. On another map you sketched out as you went along, the outlines of this field?

A. Yes sir.

Q. And that was done by the eye?

A. That was done by the eye. That does not purport to be a survey at all, like some of the other fields.

Q. That is an approximation by the eye?
A. Simply an approximation, yes sir.
Q. Now, as to the outlines about Nut Island and Peddocks Island there I see you have indicated in red and in blue two different outlines?
A. Yes sir.
Q. What does the red indicate?
A. The colors are used merely to make distinct fields observed on different days.
Q. That indicates a variation in days, and not in the character of the surface?
A. No, not at all, just the separate days, the observations.
Q. In the first place, I notice a purple spot, here indicated, what is that?
A. That is simply the outline of a sewage field on the day
1816 whose indication is just outside of the line probably. I put the date outside of the boundary on each field.
Q. Outside of that there is a surface of red, I suppose it is, what does that indicate, another day's observation?
A. Yes, that is the field on another day.
Q. Still outside of that is another body indicated by red, is that also another day's observation?
A. There are not two red.
Q. There are not two red there?
A. There are not two red there.
Q. Then my eye is defective as to color?
A. The smaller red field lying south of the Peddocks Island outlet is the sewage field observed on May 11th, 1905, and the larger field south of the outlet is the sleek field observed on May 11th, 1905, the words sewage and sleek being written closely to the outlines of those respective fields.
Q. Then, as a matter of fact on this chart, so far as it relates to the section about Peddocks Island, you have indicated sewage and sleek fields by different colors?
A. No sir, by the same color on the same day, but adding the word "sewage" or "sleek" to make the distinction between the two fields. The sewage field being always smaller than the sleek field.
Q. Now, on what memoranda or observations are these bodies indicated on this chart based?
A. The fields at Peddocks Island were taken from two sources, one on observations made by me on May 14th, 1912, which is indicated by the date, and the others are copies from fields surveyed by the Metropolitan Water and Sewerage Board in the year 1905. All fields observed by the Metropolitan Water and Sewerage Board were plotted on duplicates of the chart you have before you, and outlines were copied as accurately as possible without tracing from those original charts in the office of the Metropolitan Sewerage and Water Board.
Q. Then, except with reference to an indication of your own observation on May 14th, 1912, this chart, so far as it relates to this body about Peddocks Island is merely a copy of some other

paper that you found in the Metropolitan Water and Sewerage Board?

A. That is correct.

1817 Q. You have no way of knowing whether that is correct or not?

A. No sir. I did not go back of the charts in the possession of the Board.

Q. You simply took a copy of what you found there?

A. Yes sir.

Q. And which you were told represented certain things?

A. Yes sir.

Q. Insofar as it relates to your own observations—how did you make the observation of May 14th, 1912?

A. The observations at Peddocks were made like those at Moon Island from a boat passing through the field, and in making the observations I was aided by Mr. Frederick D. Smith, chief engineer of the Metropolitan Sewers, who also had the charts prepared for the Metropolitan Water and Sewerage Board.

Q. Have you said what color you indicated the observation of that date on this chart?

A. No sir, it is the field near the east outlet, the right hand outlet, with the date given.

Q. The date is there, that is identified by the date?

A. Yes.

Q. You made no observation, independent observation of any other outlet on any other day, as shown on this map?

A. At Deer Island.

Q. Now, in this observation of May 14th, 1912, near Peddocks Island, I suppose you traced that on another chart, as you did in the case of the Moon Island outlet?

A. Yes sir.

Q. You did that by the eye, merely?

A. Simply by the eye.

Q. Did you distinguish the field of sleek from the field of sewage; did you make any observation except by your eye as to the limits of those fields?

A. No sir, on May 14th the wind was blowing too hard to observe the sleek field. The wind was blowing over 20 miles an hour, and on such windy days it is very difficult to observe the sleek field.

Q. So that this only attempts to portray the sewage field, do you mean?

A. Simply the sewage field.

Q. Was there no sleek visible on the observation of May 14th, 1912.

A. Not noticeable, on a windy day the sleek would be broken up by the waves, so that you do not notice it. It is only noticeable on a comparatively calm day when the sleek lies on an almost

1818 unbroken field. The color of the sewage is not broken up by the waves so much, because it is in the water.

Q. So far as this chart is concerned, then, you made no attempt to indicate anything with reference to sleek on that date?

A. No sir, not at any place.

Q. Now, you have referred to Deer Island. That also made on the same day, was it not, that observation?

A. Yes sir.

Q. Also by the eye?

A. Also by the eye.

Q. And you also charted that?

A. Yes sir.

Q. And transcribed it on this as nearly as you were able to without tracing, I mean?

A. Yes sir.

Q. The same conditions I suppose existed with reference to the sleek and sewage?

A. Practically the same.

Q. As at Peddocks Island?

A. Yes sir.

Q. You made all these observations on the same day, May 14th, 1912?

A. Yes sir.

Q. Have you stated the velocity of the wind when you made these observations?

A. I obtained the velocity from the records at the Blue Hill observatory which is the most accurate observation made near Boston, and it was about 20 miles an hour, the fields being observed within quite a short space of time, within an hour of each other.

Mr. Riker: I wish to have noted an objection to this offer so far as it relates to any matter that was not based upon Mr. Fox's personal observations, that it is merely a copy and hearsay evidence, as to which the offer does not indicate any verification, and that as to the part of the chart which is stated to contain results of the witness' own observations that it is inaccurate and has not the probative value of an actual survey, having been merely made in the way of eye observations of conditions which were transferred to some other paper, and then transferred to this, and also on the ground that it is immaterial and irrelevant to this inquiry as to what the conditions were in Boston Harbor on May 14th, 1912.

1819 The Commissioner: Note the objection. Received and marked Complainants' Exhibit No. 123.

Marked Complainant's Exhibit No. 123.

Direct examination by Mr. O'Sullivan (resumed):

Q. Mr. Fox, has your eye been trained to make measurements?

A. I have had to train my eye to make a great many measurements of sewage fields because that was a large part of my work for the Metropolitan Sewerage Commission.

Q. In measuring on water areas with the eye, will you state what objects you take in making the measurements with the eye?

A. I tried to fix the location of the desired point with reference to points about the harbors, islands, head lands, buildings and other

such subjects, buoys especially, as I did in the case of Boston where the buoys were important and were easily identified on a map.

Q. The sewage fields as depicted by you in Complainants' Exhibit No. 123 vary in area; can you account for the variations in area in the sewage field; what factors operate to cause the variations?

Mr. Riker: I object to the question because it is not limited to testimony as to one or the other of two things. It does not appear whether it is intended to be limited to the cause of the variation in this particular instance or whether it is intended to explain variations generally.

The Commissioner: Note the objection.

A. Yes, sir, I can explain the variations in the different sizes of the fields.

Mr. Riker: The same objection.

The Commissioner: Note the objection.

Q. Explain, Mr. Fox?

A. The difference in the size of the sewage and sleek fields in Boston Harbor is due to several causes. First the volume of the discharge of sewage in a given time, second, the location of the outlet whether at or near the surface of the water of the harbor,
1820 or at a depth below the surface of the water, and whether the outlet is vertical or horizontal, and whether the discharge of sewage is vertical or horizontal. Then again the velocity of the discharge of the sewage affects the area of the field. The velocity of the discharge of sewage at Moon Island is higher than that at Deer Island, for example, and the tendency is to disperse the sewage more. In the same way the submergence of the outlet at Peddocks Island under certain conditions tends to disperse the sewage more than if the outlet were at the surface of the harbor. That is to disperse the sewage before it reaches the surface.

Q. Have you finished, Mr. Fox?

A. The currents in the harbor will also affect the size of the sewage field; where sewage is discharged into a calm body of water with no current, it will tend to form a smaller and thicker field of sewage than if the discharge is into a tidal current. The wind also affects the sewage fields of Boston Harbor, especially the visibility of the field and I have already explained how on a windy day the sleek field may not be visible at all. On several of the days when the observations were made, when I made the observations myself and when others have observed them with wind velocities up to 40 miles an hour the sleek field has been practically invisible. The action of the wind also tends to reduce the size of the sewage field, because the water at the surface of the harbor is turned over and over by the action of the wind which tends to disperse the sewage to a depth below the surface of the water. The effect of the wind is noticeable on the chart which is marked Complainants' Exhibit No. 123. The small fields found on the chart being days when the wind velocity was very high, and the combination of wind and current has a very marked effect in diminishing the size of sewage

fields where the wind and currents are moving in opposite directions. The smallest field on the chart just mentioned occurring on a day when wind and current were moving in opposite directions.

Q. Mr. Fox, directing your attention to Complainants' Exhibit No. 123, and to that part of the exhibit that shows some
1821 tinting confined by outlines, the tints being other than yellowish color, indicating the land areas, how would you describe what those pinkish and blueish and purple tints indicate, and also state who traced those tinted areas on this exhibit?

A. The tinted areas were placed on the chart by myself in order to make distinct the sewage and sleek fields as found on different days. The sewage and sleek fields of the same day are the same tint, but the same tints do not apply to the same days necessarily. The dates are given along the boundaries of the fields, in order to indicate the day of the observations. I am referring, of course to the pink, blue, and purple tints near the two words "outlet," and indicating the sewage areas from the Peddocks Island outfall.

Q. Will you state what further facts and observations you gathered relative to the sewage and sleek fields formed by the sewage coming from the outfall at Peddocks Island?

A. On May 11th 1905 I found from original unpublished records of the Metropolitan Sewerage Board of Boston that a sewage field existed of about 765,000 square feet or 17.6 acres at the west outlet of the south metropolitan sewer near Peddocks Island, the west outlet being the one in use at the time. The length of the field was about 1,500 feet, and the maximum width being about 700 feet. The time of observation was one hour before high water, flood current being running, and the outlet being submerged in about 38 feet of water at the time. The range of the tide was 9 feet. The wind was southwest with a velocity of 4 miles per hour. The average hourly flow of sewage was about 1,040,000 gallons per hour. This would mean .735 square feet of sewage field per gallon of hourly flow. The time taken for the sewage to disappear can be estimated by dividing the length of the field by the mean velocity in feet per second of the tidal current at that stage of the tide. The velocity of the tidal current at the time the sewage field was observed has been estimated at 1.13 feet per second which would give the period of time in which the sewage would disappear as 22 minutes, 10 seconds. On the same day, May 11th, 1905, the area of the
1822 sleek field was also determined. The area of the sewage and the sleek fields combined was about 2,640,000 square feet or 60.6 acres. The length of the field was about 3,850 feet, with a maximum width of about 1,000 feet. The area of field per gallon of hourly flow is 2.54 square feet. The time taken for the sleek to disappear was obtained by dividing the length of the field by the estimated mean velocity of the tidal current, and is 56 minutes 45 seconds.

On May 18th, 1905, a sewage field was found again about 1,740,000 square feet or 40 acres. The length of the field was about 3,000 feet, and the maximum width about 800 feet. The time of

observation was about two and one half hours after high water, ebb current being running. The outlet was submerged in about 36 feet of water at the time, the west outlet being in use. The range of the tide was 12 feet. The weather was given as calm with no wind. Taking the hourly discharge as 1,040,000 gallons, an area is found of 1.67 feet per gallon per hour. The mean velocity of the tidal current is taken as 1.91 feet per second. If the sewage disappeared 3,000 feet from the outlet and moved at this velocity, it would have taken 26 minutes 10 seconds to disappear. The combined sewage and sleek field on May 18th, 1905, covered about 2,535,000 square feet or 58.2 acres. The length of the field was about 4,150 feet, and a maximum width of about 800 feet. The area per gallon of hourly flow was 2.44 square feet. The time taken for the sleek to disappear worked out at 36 minutes 10 seconds. On May 25th, 1905, a sewage field was observed of about 540,000 square feet or 12.4 acres. The length of the field was about 1,350 feet, with a maximum width of about 600 feet. The time of observation appears to have been four and one half hours after low water, with flood current running. The outlet was submerged in about 37 feet of water, the west outlet being in use. The range of the tide was 9 feet. The wind southwest with a velocity of 15 miles per hour. Taking the hourly discharge as 1,040,000 gallons, an area is found of .52 square feet per gallon per hour. The mean velocity of the tidal current being estimated at .97 feet per second, the 1823 sewage would take 23 minutes 10 seconds to cover 1,350 feet and disappear. No sleek field data was found for this date. Probably the wind was too high to allow the sleek to be seen readily. The weather conditions were evidently such as to cause a considerable breaking up of the sewage on the surface, the wind blowing strongly against the current at the time. On May 28th, 1905, a sewage field was found of 3,860,000 square feet or 78.6 acres. The length of the field was about 4,000 feet and the maximum width was 1,600 feet. The time of observation appears to have been one and one half hours after low water with flood current running. The outlet was submerged in about 33 feet of water, the west outlet being in use. The range of the tide was 9 feet. The wind southwest with a velocity of 2 miles per hour. The hourly discharge being 1,040,000 gallons an area is found of 3.71 square feet per gallon per hour. The mean velocity of the tidal currents being estimated at 1.34 feet per second; the sewage should take 49 minutes 45 second- to move the length of the field and disappear. The combined sewage and sleek field on May 25th, 1905, covered about 6,260,000 square feet or 143.7 acres. The length of the field was about 6,300 feet and the maximum width 1,600 feet. The area per gallon of hourly flow is 6.02 square feet. The time taken for the sleek to disappear worked out at one hour and 18 minutes and 20 seconds. It will be noticed that the area of sewage field per gallon of discharge on this day was larger than any yet found. The larger fields, on May 28th, evidently represent conditions which may occur in calm weather anywhere even with a submerged sewer outlet. This matter will be discussed more larer on.

On June 16th, 1905, a sewage field of about 546,000 square feet was found, or 12.5 acres. The length of the field was about 1,700 feet and the maximum width about 350 feet. The time of observation appears to have been four hours after high water with ebb current running. Range of tide was 11 feet. The outlet was submerged in about 27 feet of water, the east outlet being in use at this time. The wind was southeasterly with a velocity of 2 miles per hour. Taking the hourly discharge as 1,040,000 gallons, an area is found of .525 square feet per gallon per hour. The
1824 mean velocity of the tidal current being estimated at 1.74 feet per second, the sewage would take 16 minutes 17 seconds to move the length of the field and disappear. No sleek field data was given for June 16th, 1905.

On May 14th, 1912 I visited the Peddocks Island outlet myself. A sewage field was visible, of about 1,740,000 square feet or 40 acres. The length of the field was about half a mile, 2,646 feet and the maximum width of about 1,000 feet. The time of observation was two and one half hours after high water, with ebb current running. The outlet was submerged in about 30 feet of water, the east outlet being in use. The range of the tide was 9 feet. The wind was southwest with a velocity of 21 miles per hour, at Blue Hill Observatory at the time of observation. The volume of sewage being discharged on that day was about 50,000,000 gallons, according to Mr. Smith the chief engineer of the metropolitan sewers of Boston. Taking the hourly discharge as 2,080,000 gallons per hour, an area is found of .836 square feet per gallon per hour. The mean velocity of the tidal current being estimated at 2 feet per second, the sewage would take 10 minutes, 32 seconds to move the length of the field and disappear. The wind velocity on May 14th, 1912, was too high to observe a sleek field.

The Peddocks Island outlet was also visited by myself in company with Mr. Smith the chief engineer of the metropolitan sewers of Boston.

In visiting Boston I made special inquiries among different authorities as to the condition of the water in the harbor in respect to pollution from the sewer outlets before and after I made my own observations. I found a sentiment prevailing in certain quarters that the condition of the water in Boston Harbor is satisfactory as far as pollution is concerned. I also found that the Massachusetts State Board of Health has fostered this sentiment, and on being requested by the Massachusetts Legislature from time to time to report on the conditions of the water and the sewer outlets of Boston, the State Board of Health has always officially held that the present methods of sewage disposal were satisfactory. I found persons thoroughly informed as to conditions in Boston Harbor who are not satisfied
1825 with these conditions, and I also found, and it is also a matter of record that the State Board of Health while approving the present methods of discharging sewage has also prohibited the setting of shellfish for the purposes of food inside the bounds of the harbor. It seemed to me important on account of this attitude of the State Board of Health to consider carefully their statements and opinion on

the different sewer outlets, and to compare these statements and opinions with what I found the true conditions were.

The following is the latest official statement of the State Board of Health of Massachusetts as to conditions at Moon Island, in their annual report to the Massachusetts Legislature, dated January 10th, 1912.

"The principal outlet for the sewage of the City of Boston is at Moon Island, where the sewage, after storage in reservoirs, is discharged in the early part of each outgoing tide. With the completion of the high level sewer of the south metropolitan system about six years ago, the quantity of sewage discharged at this outlet has been less than formerly, amounting in 1911 to about 90,000,000 gallons per day, making the total amount discharged on each tide approximately 45,500,000 gallons, and the rate somewhat more than 22,500,000 gallons per hour while the discharge continues. The sewage after discharge covers an extensive field between Moon Island and Long Island, and ordinarily moves around the southern side of the latter and between it and Rainsford Island toward the Massachusetts Bay, the sewage rapidly dispersing so that very little evidence of it is noticeable except in calm weather for a distance more than one and one half miles from the outlet. There has been no decided change in the conditions affecting the discharge of sewage at this outlet during the past year."

There is no suggestion here that improvement is needed in the present method of disposing of the sewage at Moon Island. The officials of the City of Boston, however, are not satisfied with existing conditions. I ascertained this fact from an interview with the Superintendent of the Bureau of Sewers of the Department of Public Works.

The extending of the outlet sewers at Moon Island into deep
1826 water has been considered by the Bureau of Sewers as one method of improving conditions. Investigations are almost now completed, moreover, for still another method of treating the sewage at Moon Island. The Massachusetts Institute of Technology has also been experimenting to determine the feasibility of adopting sprinkling filters, such filters to be installed on Thompsons Island. The State Board of Health apparently does not favor any of these methods of treatment, and puts its faith on disposal by dilution, approving especially the submerged outlet at Peddocks Island. These facts are apparent from a study of the latest reports on the sewage outlets in Boston Harbor. The discharge of sewage at Moon Island has several points which should be considered in relation to the proposed Passaic Valley sewer outlet at Robbins Reef in New York Harbor.

The enormous hourly discharge of sewage at Moon Island is likely to be reached by the Passaic Valley sewer after 1940, judging by the very rapid increase of population in recent years, and if there should be a continuous discharge at Robbins Reef of sewage as objectionable in odor as well as appearance, as large an area as that at Moon Island, there certainly would be a more serious nuisance created.

I found in Boston on interviewing yachtsmen, who had sailed in the vicinity of Moon Island for years that they always avoided pas-

ing either the outfalls or the sewage fields of Moon Island on account of the highly objectionable odor and appearance of the sewage fields. It is true that the Passaic Valley sewer outlet will be much more submerged than the outlets at Deer Island. The invert at the bottom of the Moon Island outlet sewers being on the average about 8 feet below the level of the harbor water at the beginning of the discharge of the sewage, but it must be constantly borne in mind that sewage fields are found at the submerged outlet at Peddocks Island as large as those produced from outlets discharging at or near the surface of sea water. So that under at least calm conditions of weather at Robbins Reef there is every reason to expect sewage fields as large as those found at Moon Island in proportion to the relative discharge of the sewage at Moon Island and at Robbins Reef, and that the odors would be equally offensive.

1827 Turning next to the conditions at Deer Island outlet at Boston, the State Board of Health thus officially describes the conditions in its report of January 10th, 1912:

"The sewage of the north metropolitan sewerage district is discharged at a main outlet at the southeasterly end of Deer Island at the entrance of Boston Harbor at all stages of the tide, the quantity discharged in 1911 probably averages about 60,000,000 gallons per day, 2,500,000 gallons per hour. The sewage is rarely traceable beyond a very limited area within a few hundred feet of the outlet, except for an oily film which is noticeable on the surface of the water in calm weather for a distance of a mile. The sewage is discharged at approximately the level of the sea at low water, and it is probable that even better results can be secured at this outlet by extending it farther into the channel, very deep water being found within a short distance of the present terminus of the sewer."

It is unfortunate that some of the facts and opinions in the above statement are at variance with facts and opinions given elsewhere by Mr. H. W. Clark, the chemist of the Massachusetts State Board of Health, and others, as given in the report upon the high level gravity sewer, which has already been cited. In fact the conditions at the Deer Island outlet appear to be quite different from what the Board of Health has stated them to be in their latest report. In 1898, with the daily discharge of two-thirds the present discharge of sewage, the Metropolitan Sewerage Board found that the sewage fields extended one mile and one and one eighth mile from Deer Island outlet with flood and with ebb currents respectively, and not merely a few hundred feet as stated by the State Board of Health in their report just quoted. The sleek area was found by the Metropolitan Sewerage Board of Boston to extend beyond the one mile and the one and one eighth miles. The Massachusetts State Board of Health also implies that the present method of the discharge of sewage at Deer Island is satisfactory, while my investigations have shown that it is decidedly unsatisfactory, judging from the evidence obtained.

1828 I found that the discharge of sewage so near the main ship channel has proved objectionable both as to odor and appearance, both to people passing the outlet and to the persons in the lighthouse in close proximity to the outlet. I found that the

odor of the sewage was particularly offensive to those employed at Deer Island Lighthouse. So serious has the nuisance become that the Federal authorities have directed the attention of the State authorities of Massachusetts to the necessity for choosing a different location for the outfall. The Massachusetts State Board of Health has suggested that conditions might be improved by simply extending the outlet of the Deer Island sewer farther into the channel, where there is a depth of 60 feet but Mr. Frederick D. Smith, the present chief engineer of the Metropolitan sewerage system of Boston, stated to me that the sewage field was so objectionable that he favored the changing of the position of the outlet to a place where the discharge could not even be seen as well as smelt. He does not favor the suggestion of the State Board of Health, just quoted above, that the outlet should simply be extended into deep water in the main ship channel. While such an extension would undoubtedly at times cause an increased dispersion of the sewage, it would cause the sewage fields to be more than ever in the path of passing steamers, to which they are already objectionable. The Metropolitan sewerage engineers of Boston, on account of the objection of having the sewage field anywhere near the main ship channel, have even made studies for carrying the sewage in a rock tunnel from Deer Island five or six miles out to the reef called the Graves, at the very outer edge of Boston Harbor, where the sewage could be discharged wholly outside of the limits of Boston Harbor.

I saw myself on different occasions when I visited the Deer Island outlet how the sewage field keeps in close proximity to the lighthouse, and this proximity has already been pointed out on the photographs which I took at the time of the visit to Deer Island.

The Deer Island situation evidently has much in common with what may obtain at Robbins reef. It is true that the Deer Island outlet seldom has more than 10 feet of water over it, even at
1829 high water, but then the volume of sewage is only a fraction of that proposed to be discharged in time at Robbins Reef, and the largest discharge at Robbins Reef may offset the effect of submergence of the outlets, as proposed by the Passaic Valley Sewerage Commission. Again, the number of persons who see and smell the sewage field at Deer Island is only a fraction of those who pass in the neighborhood of Robbins Reef throughout the year. The conditions at Deer Island are even more favorable as to the disappearance of sewage than at Robbins Reef in two respects. With flood current the sewage field at Deer Island tends to keep in near the Deer Island shore at certain stages of the tide, and is not carried so far as the sewage would be from Robbins Reef, as indicated by the floats set adrift at Robbins Reef. The distance to which the flood current at Deer Island can carry floating objects is far less than has been observed at Robbins Reef, floats having been observed by the Metropolitan Sewerage Commission to be carried distances up the Hudson River of from 6 to 7 miles from Robbins Reef.

Another favorable condition at Deer Island is the opportunity of the sewage with ebb current to spread out as it passes toward the open sea. The outlet near Deer Island is near a channel which has an

angular opening of about 90 degrees, and the sewage would be dispersed by the currents over that area, while sewage discharged at Robbins Reef would have to pass through the Narrows with ebb current, the upper Bay contracting, in the case of New York, instead of widening out, as in Boston. Where sewage is discharged into tidal currents which converge towards a narrow outlet, the result is that the sewage tends to be confined to a stream until it passes the narrow outlet, with but little dispersion and dilution, except near the sewer outlet. The most notable example of this is at Dublin Island, where the sewage discharged from the Rathmines and Pembroke sewer passes in a narrow stream in almost a straight line to the mouth of Dublin Harbor a mile away with little further dilution than that caused by rising to the surface at the outfall. The entrance to Dublin Harbor is narrow, the harbor being enclosed between
1830 two walls extending from the shores.

The Massachusetts State Board of Health describes conditions at Peddocks Island, Boston as follows, in the report of January 10th, 1912:

"The Sewage of the South Metropolitan district is discharged through a main outlet near Peddocks Island in the southerly part of the harbor. The quantity of sewage discharged at this outlet in 1911, probably averaged 40,000,000 gallons per day, and as the discharge is continuous, the average discharge per hour was 1,700,000 gallons.

While the quantity discharged at this outlet is gradually increasing, the outlet is very difficult to locate, even under the most favorable conditions. In this case the sewage is discharged at the bottom of the sea where the depth of water is 30 feet at low tide, and the sewage becomes very greatly diluted before reaching the surface."

There is one statement in this report of the Massachusetts State Board of Health which is decidedly erroneous, namely, that the outlet at Peddock's Island is very difficult to locate, even under the most favorable conditions. As already described, I visited the outlet when the wind was blowing 40 miles an hour, and waves were breaking over the boat, and yet the outlet was plainly visible as shown by the photographs already introduced and described as Complainants' exhibit No. 122.

The Massachusetts State Board of Health also states that the sewage becomes very greatly diluted before reaching the surface without any qualification as to the conditions from time to time. The statement has been made that the sewage reaching the surface of the harbor at Peddocks Island is diluted 20 times, and yet the investigations of the Metropolitan Sewerage Board of Boston in 1905 has shown that the sewage fields from Peddocks Island outlet are as large as those that would be produced by a discharge of sewage at the surface of the bay. It is evident, to say the least that the statement that the sewage becomes very greatly diluted requires decided qualifications. The Massachusetts State Board of Health says nothing about con-
1831 ditions at Peddocks Island as they exist in calm weather, leaving one to infer that there are no objectionable conditions to be observed. The investigations of the Metropolitan Sewerage

Board of Boston clearly show that large fields of sewage are produced in spite of the submergence of the outlet. The mean velocity of the current at Peddocks Island appears to be about the same as that found at Robbins Reef by the Metropolitan Sewerage Commission of New York in investigations in which I myself took part. I found at Robbins Reef a minimum velocity of .05 of a foot per second. The proposed submergence of the outlets at Robbins Reef are somewhat greater than those at the east outlet at Peddocks Island, but only slightly greater than the submergence of the west outlet at Peddocks Island, which produced such a large field as that found on May 28th 1905. It is true that a larger volume of water flows in and out through the Narrows of New York than flows by the sewer outlet at Peddocks Island, Boston, but the large volume flowing through the Narrows would not be more effective in dispersing sewage discharged at Robbins Reef than the smaller volumes passing the outlets at Peddocks Island, unless there were far greater intermixture of the sewage at Robbins Reef, with a large volume of water. That is, the mere passing of a large volume of water in the neighborhood of a sewer outlet does not determine the dispersion of sewage, but rather the volume of water passing directly over the sewer outlet. In two respects conditions at Peddocks Island Boston are more favorable for the dispersion of sewage than at Robbins Reef. The water which has once passed Peddocks Island on the ebb current does not again return into Boston Harbor, while it was found by the Metropolitan Sewerage Commission of New York, that the water passing Robbins Reef with the ebb current returns on the flood current several times before finally remaining in the lower Bay.

Q. Mr. Fox, from your observations both direct and experimental in New York Harbor, and from your observations and investigations of harbor conditions in Boston Harbor, what general relations do you find exist between the quantity of sewage discharged and the
1832 areas of the sewage fields and sleek fields respectively?

A. In the case of the sewer outlet at Peddocks Island Boston submerged in some 27 to 38 feet of water, for every gallon of hourly discharge, there has been found from .525 square feet to 3.71 square feet of sewage field, and as much as 6.02 feet of sewage and sleek fields combined. For every 1,000,000 gallons per hour discharged of sewage, this would mean from 12.1 to 85.2 acres of sewage field, and 138.3 acres of sleek field; while the submergence of the sewer outlets at Peddocks Island undoubtedly assists in the dispersion of the sewage, as it rises rapidly to the surface, this dispersion varies greatly, and on calm days, sewage and sleek fields have been found as large as if there were no submergence at all.

Having observed the conditions at Robbins Reef both of current velocities and wind, I can say there is no reason why on calm days at Robbins Reef, the proposed discharge of sewage from the Passaic Valley sewer should not form sewage and sleek fields in the upper Bay of New York at least as large in proportion to the sewage discharged as those formed at Peddocks Island Boston. If such should prove to be the *the* case, and the discharge of sewage at Robbins Reef, reaches the conservative figure of 240,000,000 gallons a day,

or 10,000,000 gallons per hour, there will be formed sewage fields as large as 850 acres, and the sewage and sleek fields as large as 1,380 acres. Even on calm days with the wind blowing 20 miles an hour a sewage field of 190 acres could be expected, and with the wind blowing 30 to 40 miles an hour a field of 30 acres could still be expected. The largest sewage fields just mentioned are as large as those formed by the discharge of sewage at Moon Island Boston, and I believe that such fields would be as objectionable in odor and appearance as the sewage field formed at Moon Island. Owing to the length of the Passaic Valley Sewer, and the proposed provisions for sedimentation, it appears likely that the sewage would reach the outfall in a highly advanced state of putrefaction, like the sewage discharged at Moon Island in Boston. This sewage discharged at Moon Island, as I have already stated, gives off offensive
1833 odors, which can be noted the moment one enters the sewage field. Offensive odors from sewage have been constantly noted by myself from sewage fields in the waters about New York City.

As sewage discharged at Robbins Reef will rise rapidly to the surface of the bay, as sewage does from the submerged outlet at Peddocks Island Boston, then proportionately large fields will be produced of putrefying sewage, like those produced at Moon Island, with odors equally, if not more, offensive. Conditions then, at Robbins Reef would be even worse than at Deer Island Boston, where the Federal Government has so objected to the discharge of sewage at that point that plans have been made to remove the outlet from the vicinity of Deer Island lighthouse entirely, and even to carry it five or six miles out to sea beyond the most remote Island in Boston Harbor.

Adjourned to June 12th, 1912, at 10:30 A. M.

Supreme Court of the United States, October Term, 1911.

PEOPLE OF THE STATE OF NEW YORK, Complainants,
vs.
STATE OF NEW JERSEY and THE PASSAIC VALLEY SEWERAGE COMMISSION, Defendants.

CORPORATION COUNSEL'S OFFICE,
NEW YORK, June 12th, 1912.—10:30 a. m.

1834 Present: James D. Maher, Esq., Commissioner.

Appearances:

Dr. William J. O'Sullivan, Special Counsel for The People of the State of New York, Complainants,
Adrian Riker, Esq., for the Passaic Valley Sewerage Commission, Defendants.

Met pursuant to adjournment.

JOHN P. FOX, a witness called on behalf of Complainants, recalled, for further examination, testified as follows:

Direct examination by Mr. O'Sullivan (resumed):

Q. Mr. Fox, if I recall rightly, you stated your estimate of the sewage field that would be produced or generated at Robbins Reef with a discharge of 240 million gallons per day from the Passaic Valley outlet sewer. Can you tell us what the area would probably be of the sewage field from a discharge of 357,600,000 gallons per day, which is the contemplated maximum discharge of the Passaic Valley Sewer in the year 1940 according to the report of the Passaic Valley Sewerage Commission of 1908.

Mr. Riker: I object to it on the ground that it does not appear from the evidence that that is a fact in the case.

The Commissioner: Note the objection.

A. I should expect the sewage fields and sleek fields to be at least 50 per cent. larger than in the case of a discharge of 240,000,000 gallons a day. That is that the sewage fields on days with calm weather would be at least 1,275 acres for the sewage field and 2,070 acres for the combined sewage and sleek fields.

Cross-examination by Mr. Riker:

Q. Your observations with reference to sewage discharge have been confined to the periods that you have testified to on your direct examination

A. Yes, sir, I think so.

Q. And confined to the sewage discharge of New York Harbor and Boston Harbor?

A. Yes, sir.

Q. In your observations in New York Harbor did you
1835 endeavor to locate the points of discharge of the sewage of the City of Greater New York?

A. You mean as a part of my work?

Q. Yes.

A. I did not undertake to locate all the outlets, but simply to examine a large number of them.

Q. How many did you examine?

A. I should say about half of those in New York City and its Boroughs.

Q. You mean by that the Borough of Manhattan and the other Boroughs?

A. Yes, sir, the five Boroughs of New York.

Q. And what else did you examine?

A. I examined in New Jersey only the outlet of the joint outlet sewer, with any degree of care.

Q. The Arthur Kill?

A. Yes, sir. I simply observed a few others along New Jersey, but I did not study them.

Q. At what depth does the joint outlet sewer at Arthur Kill discharge sewage?

A. Between high and low water, I should say, like the majority of the sewers around New York.

Q. Did you determine that by actual observations?

A. I do not remember making any special investigation, but I read the reports of the commission which built it, and was familiar at the time with the level of the outlet.

Q. Did you ever see the outlet at any stage of the tide?

A. I remember seeing it there when it was practically submerged on one occasion, but we did not pay very much attention to the New Jersey sewers in the work.

Q. Is that outlet a horizontal discharge or a vertical discharge?

A. That is a horizontal discharge.

Q. Now, the sewers which you inspected within the Boroughs of the City of New York, the City of Greater New York, did any of them discharge at a point below low water mark?

A. No, sir, except on Liberty Island, the pipes from the sewers there went out below low water mark, but I did not study the conditions there, simply noticed them studying the shores of Liberty Island. That is, some of the sewers. One sewer at Liberty Island discharges above low water mark.

Q. That is a local sewer, accommodating the inconsider-
1836 able sewage of Liberty Island?

A. That is all.

Q. Now, when did you make your observations of these sewers?

A. From June 1908 down to the present time.

Q. Do you know the population that these sewers served at that time?

A. I worked that out in great detail spending several months on it in 1909, the population of all the Metropolitan District of New York and New Jersey.

Q. I am not asking you for that; I am asking you for the population of the City of Greater New York. Do you know the population that the sewers which you have observed from that city at the date when you made your observations approximately?

A. You mean the total population?

Q. Yes.

A. No, sir, I never worked that out.

Q. You have no idea of what it was then, approximate idea?

A. Not of the population of the district drained by half the sewers I spoke of.

Q. Do you know the population that was served by all the sewers of Greater New York at the time that you made your observation?

A. The population represented by the sewers was a large proportion of the population of New York City.

Q. Well, what was that population in 1908, if you know?

A. I should say it was about three and one half millions. I do not carry those figures in my head.

Q. And with reference to the shore line, where did you observe the outlets of these sewers of Greater New York?

A. Around the entire shore line of Manhattan Island, of the

Bronx from Sapyten Duyvil to the East River; Queens, from about Blackwells Island Bridge south to the boundary of Brooklyn and Brooklyn from the boundary of Queens to Bath Beach and then the entire shore of Jamaica Bay from the western and around to the eastern end at Hammels Station, and then also the shore of Richmond Borough, from the Sailors Snug Harbor around to the eastern shore, a point near Stapleton.

Q. Have you completed your answer?

A. Yes, sir.

Q. Now, with respect to those outlets at what point with reference to the shores were the outlets located?

A. Sometimes at the original shore line in the case of
1837 beaches, sometimes at the end of pier heads in the case of piers, and at different points between pier heads and the shore line, and in some cases the sewers themselves formed piers.

Q. What was the character of the discharge from these sewers with reference to purification of any kind, so far as you observed them?

A. There was no attempt at purification for the majority of the sewers, the exceptions being the sewers discharging in Jamaica Bay. There the sewage was all supposed to be treated before discharged into the Bay.

Q. Now, confining your attention if you please to the sewers on the shores of Manhattan Island, did you discover a continuous sewage field all about the shores of the Island of Manhattan in your observations of these discharges?

A. No, sir; not a continuous field, simply fields which sometimes were continuous along the piers, but not so around the Island by any means.

Q. Do you know the population of the Island of Manhattan in 1908?

A. Not without referring to my notes.

Q. Several millions?

A. Yes, sir.

Q. Well, how do you account for it that the discharge of sewage, crude sewage, at a depth no lower than low water mark along the shores of the Island of Manhattan, did not form a continuous sewage field, about the Island of Manhattan in 1908, when you observed it?

A. There may have been more of a continuous field than I have spoken of, because I never followed the shore line of Manhattan to determine that matter. I have merely studied the sewage field from the shore, near the sewer outlets and from the Brooklyn Bridge and on one or two occasions from the boat, but there was no systematic study of the question of sewage fields.

Q. But from your studies of sewage fields, have you any question that there has existed or did exist in 1908, a continuous sewage field around the Island of Manhattan?

A. A very large sewage field, not continuous I think. Perhaps at any rate, along the Upper Hudson, where the sewers are quite a distance apart.

Q. Well, the upper Hudson, how far up do you intend by that

1838 A. Well, from 155th Street to Spuyten Duyvil.

Q. Above the Harlem—is that above the Harlem?

A. That is above the east end of the Harlem, but between 155th Street and the mouth of the Harlem at Spuyten Duyvil.

Q. But, below that in your opinion, there was in 1908 a continuous sewage field along the shores of the Island of Manhattan?

A. Well, I never studied that, but the amount of sewage was very large.

Q. You were not directed to study that?

A. No, sir.

Q. Your study was directed to the problem of the effect of the proposed Passaic Valley Sewer.

A. No, I was studying the discharge from single sewers and sometimes from groups of sewers, but never the whole field around the Island of Manhattan.

Q. Do you happen to know whether the population of the Island of Manhattan as distinguished from Greater New York has materially increased in the last 10 years?

A. Very much so, much more so than any one expected.

Q. Now, you have testified to a sewage field, I think it was a sewage field existing from about a recreation pier; do you remember that?

A. Yes, sir, at West 50th Street.

Q. Do you know when that sewer was built?

A. No, sir; I may have the date of it in my book here.

Q. You cannot remember it?

A. I do not remember the date.

Q. Do you remember, or do you happen to know whether it was built before the recreation pier was established there by the City of New York or after?

A. No, sir, I do not know.

Q. Well, have you seen the recreation pier in use by the people of the City of New York?

A. Yes, sir.

Q. When have you seen it in use; what seasons of the year?

A. In the summer.

Q. And the effects of a sewage field, are they more or less objectionable in summer than at other seasons of the year?

A. They are more objectionable, very much more so.

Q. Was the pier in use by people at the time when you observed it?

A. Yes, sir.

1839 Q. Now, your observations in Jamaica Bay, Mr. Fox, what is the depth of Jamaica Bay, can you state?

A. Anywhere, I should say off hand, from 30 feet at Rockaway Inlet to nothing. The Bay decreases gradually in depth from the outlet, which is the deepest part.

Q. Is there any marked current in Jamaica Bay?

A. Yes, sir. There is a very rapid current at the outlet, at Rockaway Inlet, and I found rather marked currents off Bergen Beach with lesser ones as I went north.

Q. And did you trace the cause of these currents, what were they due to?

A. No, sir, I simply traced the currents and formed opinions as to what the cause was.

Q. Are there any considerable streams of water discharging into Jamaica Bay?

A. Not of fresh water, merely salt water; that is creeks.

Q. Now, with reference to the depth limits, the limits of depths of Jamaica Bay, where were the sewer outlets located as you observed them.

A. The outlet of what is called caisson No. 4, near Coney Island is in a shallow creek. The outlet of three sewers north of there is in Paerdegat Creek at different points of the creek.

Q. Is that a deep creek?

A. That is not a deep creek compared with the Newtown Creek, but an ordinary tidal creek, I should say.

Q. Can you approximate its depth?

A. Not without reference to my notes.

Q. Not even approximately?

A. I should say it might be 6 or 8 feet deep at high water.

Q. Well, now, what other outlets, sewer outlets?

A. The outlet of the largest sewer in Jamaica Bay is at the mouth of Second Creek, which is where the flume from the 26th Ward sewer comes practically into the Bay. The Sewer does not empty into the creek itself, but into the Bay at the mouth of the creek.

Q. At what depth?

A. I did not sound the depth of that creek at all.

Q. Do you know what the depth is?

A. No, sir, it is not very deep there probably, because that end of the bay there is fairly shallow.

Q. Now, I think you observed a sewage field in Jamaica Bay, did you not?

1840 A. Yes, sir, I observed several sewage fields.

Q. And caused by the sewers which you have mentioned, or any of them?

A. Caused by those and two or three others. I have only mentioned two of the fields in Jamaica Bay, however.

Q. Does this field that you observed extend over the deep water of Jamaica Bay?

A. With the ebb current the field from the 26th Ward sewer did. It was carried along the main channel from Canarsie to the south and the field from Bergen Beach was carried along the deeper water off Bergen Beach.

Q. Are the currents in Jamaica Bay that you observed, anything more than tidal currents in your opinion?

A. No, sir, merely tidal currents. There is some ground water flowing into the bay, but I know of no concentration of the fresh water into any stream there.

Q. Now, this term that you use "sewage field" is that a well defined term that was recognised at the time when you made these observations?

A. Yes, sir; that is a common term used in sewage work.

Q. Have you made a specialty of sewage work up to 1908?

A. No, sir.

Q. You have learned since that that *that* was a term that was in common use at the time when you began your observations?

A. Yes, sir.

Q. Well, now, just what does it mean?

A. A sewage field is a field of sewage floating on the surface of a recipient body of water which is limited by the visibility, the color or turbidity of the sewage and the presence of floating or suspended particles originating in the sewage. A sewage field is commonly regarded to end when the color or turbidity are too faint to be readily noticed, or the floating or suspended sewage particles are too much dispersed to be readily noticed.

Q. Is the test then the question of whether it is visible or not?

A. Yes, sir.

Q. And as soon as the presence of sewage on the surface of water is visible to the naked eye that constitutes a sewage field?

A. If the sewage is in a continuous field. You hardly call a patch of sewage on the water a sewage field.

1841 Q. How large must it be to be a sewage field?

A. Well, if it is continuous from a sewer outlet, it might be 25 feet in diameter.

Q. Do you give that as the result of an accepted definition found in any authority?

—. Well, there is very little in the way of accepted authority on the subject because it is a new subject that I have had to take up largely at first hand.

Q. You mean to say that the accumulation of sewage matters from sewers upon the waters of bays and streams is a new matter?

A. No, but the study of it, the study of laws governing sewage fields is almost an unknown study.

Q. Just what laws are there that apply particularly to sewage fields as distinguished from any other floating matter upon the surface of waters; what are the laws that you refer to?

A. The laws are mostly the laws which I have worked out myself and the few which were worked out in Boston by the engineers since 1898.

Q. Now with what particular phenomena of the sewage fields are your laws that you have worked out concerned?

A. With the question of the dispersion of sewage and the odors from sewage fields.

Q. Anything to do with the visibility of these fields?

A. Yes, that is a part of the study of dispersion.

A. The sleek covers both what is called a sewage field and the sleek field; are they both visible?

A. They are both visible.

Q. Now, how do you distinguish them?

A. The sleek covers both what is called a sewage field and the sleek field, being a thin film of greasy or oily substance originating in the sewage.

Q. Visible to the naked eye?

—. Visible to the naked eye and infinitesimally thin, simply floating on the surface of the water. The sewage field is that part of the sewage field and sleek field combined, where you have not merely the sleek on the surface, but also have the color and turbidity of the sewage, and where floating or suspended particles from sewage are plainly visible in fairly close proximity to each other.

1842 Q. And how much substance of thickness has this socalled sewage field?

A. Anywhere from 5 feet, as found at Moon Island Boston, up to a fraction of an inch.

Q. You say as found, did you find it at Moon Island?

A. No, sir, I did not take any samples at Moon Island.

Q. You did not make any measurements of these sewage fields at all?

A. Measurements, but no chemical analysis, to determine the depth at which you can see the sewage.

Q. How can you determine the depth of the sewage unless you make chemical analyses from the different depths?

A. You can determine it by taking samples of water at different depths and observing the turbidity and color and the suspended particles at different depths, without needing to make chemical analyses.

Q. You can determine whether that is sewage or whether it is some other kind of pollution, can you, by observation?

A. You can if there are no other marked sources of pollution near.

Q. If you have excluded every other possible source of pollution, then you can conclude that it is sewage, is that it?

A. Yes, sir.

Q. That is the only way that you can tell from your observation, unless you make chemical analyses, is it not?

A. You cannot determine sewage fields by chemical analysis satisfactorily.

Q. You can determine by chemical analysis one feature of it, and an important one and that is whether it is sewage matter that is polluting the water or not?

A. Yes, sir.

Q. That is a rather important factor, is it not, in determining the sewage field, to know that it is sewage?

A. Yes, sir.

Q. When did you make your trip to Boston for the purpose of examin-g the harbor there and the outlets of the sewers?

A. In May of this year.

Q. And you examined all the outlets of all the Metropolitan sewers in the harbor, did you?

A. Yes, sir, and of one or two others.

Q. Taking the Moon Island outlet, at what depth did you say that was discharging?

1843 A. At the beginning of the discharge, the top of the gate is about 3 feet below the level of the harbor water and the bottom of the outlet sewers about 8 feet below the level of the harbor water.

Q. And at the end of the discharge?

A. At the end of the discharge the bottom of the gate would be about the level of the harbor water, the discharge lasting about 2 hours.

Q. And the discharge itself what depth would that be below the surface of the water?

A. That would bring the level of the sewage, as it passes under the gate at about the level of the harbor water.

Q. So that the average of the discharge was at what depth?

A. That depends on whether you take the average by time or by volume of sewage, because there is more sewage discharged at the beginning of the two hours than towards the end.

Q. Why is that?

A. On account of the head of sewage in the reservoirs.

Q. It is a question of hydraulic pressure then?

A. Yes, sir.

Q. Taking the volume of the sewage as distinguished from the time of the discharge, have you formed any approximation as to the depth at which the average discharge is made in Boston Harbor from the Moon Island outlet?

A. I did not make any calculation with regard to that.

Q. It certainly is not 8 feet, is it, on the average?

A. No, sir.

Q. Is it more than 4 feet?

A. 8 feet is the maximum.

Q. It is more than 4 feet?

A. I should say the center of the discharge at the outlet there might average 4½ or 5 feet.

Q. Now, this boiling phenomenon that you have described, to what do you attribute that.

A. At Moon Island you mean?

Q. Yes.

A. To the fact that the sewage is discharged below the surface of the harbor water at the beginning of the discharge.

Q. Any other reason?

A. The sewage rises to the surface forming a boiling action, and it also has this high horizontal velocity.

Q. And is the discharge horizontal or vertical?

A. The discharge is oblique the sewage rising to the surface, and also moving in a horizontal direction.

1844 Q. Is the pipe, the outlet pipe, the discharge pipe, horizontal, vertical or oblique?

A. The outlet sewers are horizontal, but the sewage forms an eddy against the gate so there are a number of directions of the discharge.

Q. There is a gate beyond the mouth of the sewer which serves to deflect the flow of sewage?

A. The gate is just inside the mouth of the outlet sewers.

Q. Well, it serves to deflect and turn in an upper direction, does it not, the flow of the sewage?

A. Some of it, some of the sewage is deflected up, some back, some forward.

Q. Do you think that is the cause of the boiling in connection with the head under which the sewage is discharged?

A. No, sir. The gate is under the gate house, and the boiling is seen outside of the gate house.

Q. Now, if the sewage or any other liquid discharging through that pipe is deflected by the gate, some of it upward, would not that account for the boiling action that you have seen?

A. Not for the boiling action outside of the gate house.

Q. Then what is it due to?

A. Due to the rising of the sewage to the surface.

Q. Certainly, but what causes that to rise to the surface so as to produce the boiling action?

A. The lighter specific gravity of the sewage.

Q. Do you observe that at the discharge point of every sewer?

A. Yes, sir, in salt water or brackish water.

Q. You have observed the boiling action at the point of discharge of every sewer that has discharged into salt water, in your observations?

A. I observed the lighter specific gravity of the sewage.

Q. But I want to know whether you observed this boiling action at the outlet of every sewer that has come under your observation?

A. Yes, sir, I have noticed it at Deer Island and at Peddock's Island and occasionally around New York City, where the mouth of the sewer was submerged at high water at West 50th Street, for example.

Q. You say you observed the joint outlet sewer discharging
1845 into the Arthur Kill on one occasion?

A. Yes, sir.

Q. Saw the pipe under water?

A. Yes, sir.

Q. Did you observe the boiling there?

A. I observed the sewage coming to the surface, but with not so much of a boiling action as at other times and places.

Q. Do you know what the discharge from that sewer is?

A. I could not tell you offhand.

Q. Do you know what causes the sewage matter to rise to the surface?

A. The lighter specific gravity of the sewage than salt or brackish water.

Q. Is that difference in specific gravity in your opinion due to the fact that it is sewage, or is it due to the fact that it is fresh water as distinguished from salt water?

A. It is due to both. There are greasy substances in sewage floating and in suspension, which tend to rise, and there is also the fresh water in sewage which tends to rise in salt or brackish water.

Q. Yes, well, the greasy matters and other matters that have a less specific gravity even than fresh water would naturally rise to the surface would they not?

—. Yes, sir.

Q. And the water, that is as it may be distinguished from the foreign matter in it would rise, being fresh water if it is discharged into salt water?

A. Yes, sir.

Q. Does the temperature have anything to do with it?

A. Yes, sir, the temperature would affect the specific gravity somewhat.

Q. Now, did you observe the places of confinement of the sewage at Moon Island before the discharges of it were made?

A. Yes, sir.

Q. What were they, what are they?

A. They consist of four reservoirs containing in all, when full about 50 million gallons.

Q. Open reservoirs?

A. Open to the air.

Q. How deep?

A. I could not say offhand.

Q. How far were these reservoirs from the point of discharge?

A. Several hundred feet, perhaps between 200 and 400 feet to the most distant reservoirs.

1846 Q. How long is the sewage allowed to accumulate in the reservoirs?

A. Ten hours.

Q. Did you attempt to determine the relative temperature of the sewage in these reservoirs and the water in the bay?

A. No, sir, I never have done that.

Q. Is not that a question of any interest in the matter of determining the laws which would govern the formation of sewage fields?

A. The effect of temperature would be very small compared with some of the other factors which would influence it.

Q. Don't you think that is an important element to take in?

A. Important, but not so important as other factors.

Q. Not important enough for you to take it into account, you did not take it into account?

A. Important, but not important enough to take up at this time compared with the other factors.

Q. Now, what are the other outlets in Boston Harbor. I am now speaking of the Metropolitan Sewerage District outlets?

A. Deer Island and Peddock's Island.

Q. Now, the Deer Island outlet, what is the depth below the surface of the water of that outlet?

A. The top of the outlet is at practically mean low water.

Q. Is it a vertical discharge or a horizontal discharge?

A. A vertical discharge.

Q. And Peddock's Island, what is the depth of that outlet?

A. The east outlet is 24 feet below mean low water and the west outlet 30 feet below mean low water.

Q. Horizontal or vertical?

A. Vertical.

Q. Under what hydraulic pressure is the sewage discharged from those outlets?

A. At Peddock's Island the ordinary level of the sewage is sometimes below that of the water in the harbor causing the sewage to back up. At Deer Island, I do not know the level to which the sewage is pumped there. I did not observe the gauges, but the head is slight compared with that at Moon Island.

1847 Q. Now, in your observation of the sewage fields, as you have observed them, at all the outlets in Boston Harbor, where is the sewage field most perceptible?

A. The largest fields are those produced by Moon Island, but the largest fields per gallon of sewage discharged have been found to be about the same at the different outlets. In other words all three of the outlets produce practically equally large fields per gallon of hourly discharge.

Q. When you say equally large fields, just what do you mean by that; do you mean area or cubical content?

A. I am speaking now of the area.

Q. Did you make any attempt to determine the cubical contents of the different fields?

A. I have made some estimates of that.

Q. Do you think that in Boston Harbor these different outlets produce an equal field in cubical contents, in proportion to the sewage discharged?

A. No, sir. The Moon Island field is deeper, on the whole, than the Deer Island and the Peddock's Island field of course is different from the others, in having a volume of sewage at one end of it, at one point, which you might say causes a greater depth than the others, but the depth is due to the ascending columns of sewage of course.

Q. That is at the point of discharge. You do not mean to say that is any fair measurement of the depth of the sewage field, do you?

A. No, only it must be taken into account somewhat.

Q. I was asking you for the cubical contents of the different fields; if you had any estimate of that and the proportion which that bore, respectively to the sewage discharge at the outlets respectively?

A. I have made some figures on that.

Q. Well, what is the result of your figures on that, if you can give it?

A. The data was not sufficiently accurate to give any satisfactory results. It has to be based on chemical analyses, and the analyses were too uncertain and contradictory to base conclusions on.

Q. Were you making investigations to attempt to determine the laws that govern the formation of these sewage fields?

1848 A. Yes, sir, I was attempting to get at the absolute laws and did not start out with any preconceived idea in any way.

Q. You were endeavoring to secure data from which you could deduce the laws?

A. Yes, sir.

Q. Well, did you attempt to deduce the laws which govern the formation of sewage fields from sewage discharges at different depths?

A. Yes, sir.

Q. Well, is not the cubical contents of the field of importance as

one of the data upon which you could deduce a law governing the formation of a sewage field from an equal amount of sewage at different depths?

A. It is important, but there are no data as yet sufficiently satisfactory to take it into account.

Q. And you did not have the means at your disposal in the Boston Harbor observations to acquire the data necessary for that purpose?

A. No, sir, the data may have been in existence, but I could not obtain it if it was.

Q. Well, now, just what data did you observe and just what laws did you deduce that are of importance in this inquiry in your opinion?

A. I examined all the data that I could obtain access to in Boston, from the sources I have mentioned, the Metropolitan Water and Sewerage Board and the Sewer Department of Boston, and the most important laws which I found were those which showed the area of a sewage field and sleek field produced by different volumes of sewage discharge, under different conditions as to wind and depth and the currents.

Q. Now, will you state the law as you have deduced it, which governs the extent and area of the sewage field from an outlet discharging a given amount of sewage, at a depth of 10 feet and the same sewage discharged at a depth of 40 feet?

A. It is impossible to deduce any law as yet in regard to the effect of depth upon an outlet because the data is very meagre. There are very few large sewers discharging at any depth below the surface and the different conditions particularly of weather and current affect the result so much that no law could be deduced. I found, for example, that at Peddock's Island, Boston, a dilution of 20
1849 times had been observed. But I also found that sewage fields had been observed there as large as if produced by a discharge of sewage at the surface of the water. The differences in the conditions, in other words, are so great that no law can as yet be determined.

Q. Now, in your direct testimony, Mr. Fox, I have observed that you said that you had observed the conditions at Robbins Reef in this harbor, both of current velocities and winds, and that there was no reason why on calm days at Robbins Reef the proposed discharge of sewage from the Passaic Valley Sewer should not form sewage and sleek fields in the upper Bay of New York at least as large in proportion to the sewage discharged as those formed at Peddocks Island, Boston. How do you reach such conclusion in view of your present testimony?

A. I reached that because I found that while the submergence of the outlet at Peddocks Island, causes, at times, a marked reduction in the size of the sewage field, compared with outlets near the surface of the water, there were also large sewage fields observed there, which were as large as those produced by the large sewer discharging at the surface. I found that the mean velocity of the currents at Ped-

docks Island were approximately the same as at Robbins Reef, from the data available for the study and I also found that the area of open water west of Robbins Reef, toward the prevailing wind was somewhat less than at Peddocks Island, so that the conditions at Robbins Reef in respect to current and wind were about the same as at Peddocks Island. The proposed depth of the outlets at Robbins Reef is about 10 feet greater than the west outlet at Peddocks Island, which produced the largest fields I found, but in vie wof the large field produced by the sewage at Peddocks Island, I believe there will be times at Robbins Reef, even with the greater depth of 10 feet when you will get fields as large, in relation to the hourly flow, especially on account of the proposed method of dispersion at Robbins Reef.

Q. So that in order to reach your conclusions and establish the laws, as a matter of fact you do not require the results of obeervations of actual discharges at a depth of 40 feet?

A. No, sir; I thought so at first, but the results at Ped-

1850 docks Island——

Q. Furnished all the data you needed?

A. That shows that at times the depth would not prevent the large fields although it must be admitted that the depth does influence the dispersion. One must not take a one sided view on any matter like that. I was trying to get at the facts and not to fit a theory to conditions.

Q. You were retained by the Metropolitan Sewerage Commissioners, were you not?

A. I am not connected with the Metropolitan Sewerage Commission now.

Q. I said you were retained when you made the observations?

A. The observations of 1908 and 1909, but not the present observations in Boston.

Q. You were retained by the Complainants in this case for your present observations, were you not?

A. Yes, sir, I was retained to get at the truth about sewage fields.

Q. You were retained by the Complainants in this suit, were you not?

A. Yes, sir.

Q. And under their directions you made these last observations, did you not?

A. Partly and partly on my own initiative to get at the facts.

Q. And you knew that your testimony was to be used by the Complainants in this litigation did you not?

A. No, sir, I was simply trying to get at the facts without any regard as to whether the facts would be used or not.

Q. You did not expect to testify in this case?

A. I expected to testify merely in regard to my work for the Metropolitan Sewerage Commission.

Q. And not as to the result of your observations in Boston Harbor?

A. Not until I had worked the subject out, the subject of sewage fields.

Q. Who paid your expenses in Boston?

A. I paid them all myself, sir.

Q. You are going to collect them from the Complainants in this case?

A. I do not know whether they will pay them or not.

Q. You will put them in as a charge, you expect to?

A. Only my railroad fare on one trip; up and back once.

Q. Now, when you testify as to the proposed discharge of sewage from the Passaic Valley Sewer, exactly what is the proposed
1851 discharge upon which you testify?

A. I used in the first place——

Q. I do not care what you used, I want you to state what it is. I want you to tell me what the basis is of the proposed discharge upon which you are founding your direct testimony?

A. I used the figures which you gave in your answer, I think, the figures of 250 million gallons a day as a maximum dry weather flow, as I remember, in 1940.

Q. What else?

A. I also used yesterday the approximate figure of 360 million gallons a day, which I understand is the maximum possible discharge of the sewer.

Q. That is the figure that you used anyway, whatever it is 360 million gallons a day?

A. I used 240 million gallons myself in my estimate.

Q. Now, what else, with reference to the proposed discharge?

A. I also considered the depth of the outlet.

Q. What depth?

A. 40 feet at mean low water.

Q. What else?

A. The requirements of the United States Government as given in the agreement between the Unitd States Government and the State of New Jersey.

Q. What else?

A. I used the observations on currents as determined by the Metropolitan Sewerage Commission, and took into account my own personal observations.

Q. I am asking you now as to the proposed discharge of the Passaic Valley Sewer: What were the elements that you took into consideration?

A. I am just stating these, the volume of sewage and the conditions.

Q. I want to know just exactly what you understand the Passaic Valley Sewer proposal is, what you understood when you gave that testimony. I understand you say there is to be 240 million gallons of discharge in dry weather flow at a depth of 40 feet and the conditions that are involved in the stipulation with the United States Government; now what else is there if anything?

A. I took into account the weather conditions in making the estimates of different sized fields.

Q. Is that any part of the proposal of the Passaic Valley Sewerage Commissioners?

A. The weather conditions affect the estimates of the fields
1852 very markedly of course.

Q. But you referred in your direct testimony to the proposed discharge from the Passaic Valley sewer. Now I want to know just what you had in mind as that proposed discharge from the Passaic Valley sewer. You have given 240 millions of gallons in dry weather flow, at a depth of 40 feet and you have referred to the stipulation. Was there anything else that was involved in the proposal as you understand it?

A. By the stipulation, I include, of course, all the stipulations including the coarse screens, settling basins, the mechanical screens, as well as the method of dispersion.

Q. Did you take into consideration the hydraulic pressure of the discharge?

A. Yes, sir.

Q. What was it?

A. I did not estimate it, but simply compared it with the pressure at Moon Island.

Q. If you did not know what it was, how did you take it into consideration?

A. Simply by considering whether it was a vital factor in the matter.

Q. And you concluded that it was not a vital factor in the matter?

A. I estimated it early in the study of the matter of the discharge.

Q. You estimated it; what was your estimate based on; was it part of the proposal of the Passaic Valley Sewerage Commissioners as you understand it?

A. Yes, sir.

Q. What was it, how much?

A. I do not have the figures here.

Q. Is the discharge vertical or horizontal, as proposed, as you understand it?

A. The discharge as stipulated by the United States Government is to be horizontal.

Q. Then it is proposed to be horizontal as you understand it, that is part of the proposition?

A. As propsed by the Government, yes, sir.

Q. Do not you know that the Passaic Valley Sewerage Commissioners in the State of New Jersey have agreed to do that thing and that is part of their proposal?

A. I suppose that is their proposal.

1853 Q. You took it into consideration as part of their proposal, did you not?

A. Yes, sir.

Q. You took the whole stipulation as part of the proposal?

A. Yes, sir.

Q. Did you take into consideration that the Passaic Valley Sewerage Commissioners proposed by their stipulation with the United States Government, that there will be absence in the New York Bay,

of visible suspended particles coming from the Passaic Valley Sewage?

A. Yes, sir.

Q. You took that into consideration, did you?

A. Yes, sir, all of them, yes, sir.

Q. I asked you as to that one?

A. Yes, sir, that particular one.

Q. And under that proposal do you say there will be sewage fields formed in New York Bay from the discharge of the Passaic Valley sewer?

A. Unless the Passaic Valley Sewerage Commissioners adopt radically different treatment from what is required by the United States Government in the agreement.

Q. I am directing your attention to this part of the proposal of the Passaic Valley Sewerage Commissioners that there will be absence in New York Bay of visible suspended particles coming from the Passaic Valley Sewerage and ask you whether in view of that proposed discharge you will say that there will be sewage fields and sleek fields formed in New York Harbor from the discharge of that sewer?

A. If there are no suspended particles in the water, they will be absent, of course in any sewage field, but that will not prelude the formation of sewage fields, because sewage fields will be formed if there is color and turbidity, of course.

Q. So that if the proposal as embodied in this stipulation is carried into effect, there will be no suspended particles coming from the Passaic Valley sewage?

A. If there are no particles there will be no particles.

Q. Did you take into consideration that the proposal involves the absence in New York Bay or its vicinity of odors due to the putrefaction of organic matters contained in the Passaic Valley sewage thus discharged?

A. Yes, sir.

Q. And if that proposal is carried into effect you say
1854 there will be sewage fields and sleek fields formed in the harbor of New York from that discharge?

A. The absence of odors would not preclude the formation of sewage fields.

Q. Is the proposal, as embodied in the stipulation with the United States Government, that there will be practical absence on the surface of New York Bay of any grease or color, due to the discharge of the Passaic Valley sewage at the dispersion area or elsewhere, in connection with the other proposals which I have drawn your attention to, will you say that there will still be sewage fields formed in New York Bay from the discharge from the Passaic Valley sewer?

A. The prevention of sleek will not affect the sewage field. It would simply affect the sleek field. If there is no sleek discharged whatever, there will be no sleek field, but the sewage field could still be there.

Q. That is the grease, the sleek field, due to the color, due to the discharge of the Passaic Valley sewage, is to be absent, and do you

say that there will still be sewage fields in New York harbor if that proposal is carried into effect?

A. If color alone is absent the sewage particles, of course would still be visible. You must have combination of them all.

Q. I ask you that the other proposals which I have read to you should be taken in connection with this one, that there will be no color visible in New York Harbor from sewage discharged from this proposed sewer, that being so, do you still say there will be sewage fields and sleek fields formed?

A. If you have no colored discharge together with no visible suspended particles and no odors and no turbidity due to clay matter, for instance, from storm water, that must be taken into consideration, besides these, because storm water will form sewage fields, besides other things.

Q. Why are you referring to storm water as distinguished from the other discharge through this sewer?

A. Because storm water indicates the boundary of the sewage field more or less.

Q. And is not the characteristic of the sewage field, that
1855 you have already noted as the chief one, the visibility of the sewage matter?

A. That is the chief factor, of course.

Q. Now, you have in your direct examination said that under the conditions you observed there is no reason on calm days at Robbins Reef why the proposed discharge from the Passaic Valley sewer should not cause fields of sewage and sleek fields. Now, I ask you, having drawn your attention to the proposed discharge, as it is formally stipulated to be made with the United States Government, I ask you whether, having those proposals before you, you still say that there is no reason why sleek fields and sewage fields should not be formed in New York Harbor?

A. I still say that taking into account the entire stipulation with the United States Government and not merely the part indicated, you will have sewage and sleek fields in New York Harbor.

Q. In other words, you have undertaken to construe the legal effect of this stipulation, have you?

A. I have taken into account the requirements of the Government regarding the treatment and the effect on the stipulation with regard to visibility of particles, color and sleek.

Q. Have you taken into consideration in that regard the proposal in the stipulation which you say you have read, which provides that in case the requirements of the War Department in granting the permit asked for are inconsistent with or modify the plans and methods hereinbefore set forth, then the plans and methods herein stated are to be modified to comply with the requirements of the War Department?

A. Yes, sir, I have read that.

Q. And you still say that because you do not believe the means that are specified in this agreement will produce the results which are stipulated, therefore those results will not be reached, is that it?

A. No, sir.

Q. What do you mean?

A. The results can be reached, if the Passaic Valley Sewerage Commissioners wish to reach them and take the proper means to do it.

Q. You do not believe that the proposal under which we
1856 are now working, and which we are bound to carry out and which was before you when you testified, you do not think that that will produce these results?

A. I have my doubts if the results are reached under what the Passaic Valley Sewerage Commissioners propose to carry out, unless I know more to the contrary.

Q. You think the Passaic Valley Sewerage Commissioners have sort of a mental reservation as to the carrying out of the agreement which they made with the United States Government?

Mr. O'Sullivan: I object to that question.

The Commissioner: Note the objection.

A. No, sir, not so much that as I think they are not aware of the ineffectiveness of the proposed treatment of the sewage in preventing the nuisance; that is the formation of sewage and sleek fields.

Q. And they do not intend to adopt any other in case it is found that these methods are ineffective in producing the result they have stipulated for.

Mr. O'Sullivan: I object to this question. Now we are in the field of psychology asking a witness who has testified as to the laws governing the discharge of sewage what the psychic process of the Passaic Valley Sewerage Commissioners in the future shall be. I object to anything beyond the domain of the direct or anything obtained on the cross-examination.

The Commissioner: Note the objection.

A. I have no reason to believe that they will not do what the government requires. I would not cast any aspersions on the Passaic Valley Sewerage Commissioners, not having made a study of them in any way.

Q. You have attempted to give your understanding of this stipulation. Do not you understand that this stipulation absolutely provides that the Passaic Valley Sewerage Commissioners of the State of New Jersey shall attain the results which are specified in this stipulation?

A. Yes, sir, but I was merely trying to point out that the
1857 proposed treatment of the sewage as required in the stipulation would not produce the results which are also required in the stipulation.

Q. Then you are limiting your testimony now to the part of the proposal which embodied its specific means or appliances for producing the results, are you?

A. I am trying to consider the entire stipulation.

Q. You do not intend to be understood as testifying that it is impossible to produce these results in the discharge from the Passaic Valley sewer?

A. No, sir, I have no reason to say that it is impossible under certain conditions.

Q. If it is possible under certain conditions, it is possible, is it not, if the conditions are not impossible conditions?

A. So far as I know, I have not come here to testify on the details of sewage disposal.

Q. You have, in your direct examination, attempted to testify as to the result of the discharge of sewage at Robbins Reef from this proposed sewer under the proposed plan of the Passaic Valley Sewerage Commissioners; you have undertaken that?

A. Yes, sir, only to the extent that I have knowledge to base my conclusions on.

Q. Your testimony then, does it amount to more than this, that if that amount of sewage is discharged at that point, under the same conditions, and in the same general state as the discharge in Boston Harbor, there will be sewage fields and sleek fields formed in New York Harbor?

A. It is not simply a comparison of Boston Harbor and there. It is a conclusion based on a study of sewage discharge in this country and Europe under different conditions. I merely compare one example in Boston for the sake of making a direct comparison, but the conclusions are based on a wider study than merely Boston.

Q. Now, in your direct examination I find that you state that owing to the length of the Passaic Valley Sewer and the proposed provisions for sedimentation, it appears likely that the sewage would reach the outfall in a highly advanced state of putrefaction like the sewage discharged at Moon Island in Boston. This sewage
1858 discharged at Moon Island gives off offensive odors. Did you estimate that it was your opinion that that will be the condition in New York Harbor under this proposal of the Passaic Valley Sewerage Commissioners?

A. Yes, sir, unless the method of treatment required in the stipulation is radically changed.

Q. How much experience have you had in the method of the treatment of sewage; what do you know about it?

A. I have not had extended experience, but I think I have enough knowledge to make that statement.

Q. Are you a sanitary engineer?

A. No, sir, but I have been on two occasions sanitary inspector for the Metropolitan Sewerage Commission, and have made detailed investigations in different cities, but I am not an expert on sewage disposal.

Q. Having the proposal as embodied in the stipulation in your mind, Mr. Fox, do you say that conditions at Robbins Reef will be even worse than at Deer Island, Boston?

A. Yes, sir, because the sewage fields will be larger.

Q. Notwithstanding the proposal involves that there shall be none?

A. Yes, sir, unless the proposed method of treatment was radically changed.

Q. And that is an opinion of yours not based upon any expert knowledge of the processes of sewage purification or disposal?

A. It is based on my observations of sewage disposal, but not upon an expert knowledge.

Mr. Riker: That is all.

Direct examination by Mr. O'Sullivan (resumed):

Q. Mr. Fox, Mr. Riker asked you to assume that in the discharge of the outfall at Robbins Reef from the Passaic Valley Trunk sewer, to assume that no odor would be present, no suspended matter could be detected, no visible particles could be seen, neither could any floating matter of any kind, that there would be an entire absence of turbidity, there would be no sleek and no matter in solution. Can you assume any better definition for filtered water than that?

A. No, sir.

Mr. Riker: I object to the question because it does not—insofar as the question involves statements which were not submitted to this witness by me.

1859 Mr. O'Sullivan: In answer to Defendants' Counsel, Complainants' Counsel desires to state that this is merely a summary of the detailed cross examination of Counsel for the defense. He has assumed a condition which this witness has stated positively would not result from the treatment proposed in the stipulation entered into between the Federal Government and the State of New Jersey, and I am grouping these factors to point out the impossible factors in the hypothesis of Counsel for the defense.

The Commissioner: Note the objection.

Q. Mr. Riker in the course of his cross examination asked you relative to the cubical contents of sewage fields in your studies on dispersion areas. I ask you what is the density of a sewage field dependent on. You have already related that it is dependent on currents and wind. Can you give us any other factor than these?

A. It is dependent upon the number and form of the outlets and the velocity of the discharge very markedly, besides the other factors.

Q. Does the relative density of the recipient water, as to its salinity or otherwise, play an important part when considered with the specific gravity of the sewage itself?

A. Yes, sir, I should have mentioned that. The larger the proportion of sea water in the recipient body of water the larger will be the sewage field, because the lighter sewage rising to the surface of the body of water, will spread out more if the percentage of sea water is larger in the recipient body, than if the per cent of sea water is low.

Q. Is it or is it not a recognized fact that sewage is of higher temperature than the bodies of water into which it is discharged in these latitudes?

A. It is sometimes very markedly higher in temperature.

Q. Does that act as a factor in giving it buoyancy?

A. That is one of the factors in determining its buoyancy, and its rising to the surface or its spreading out.

Mr. O'Sullivan: That is all.

1860 FLOYD J. METZGER, a witness called on behalf of Complainants, being first duly sworn, testified as follows:

Direct examination by Mr. O'Sullivan:

Q. Are you connected with any of our teaching institutions?
A. I am.
Q. What one, Professor Metzger?
A. Columbia University.
Q. In what capacity?
A. I am Assistant Professor of Analytical chemistry at the present time and have been for the past 5 or 6 years, head of the Analytical Department.
Q. Assistant to whom?
A. Strictly speaking, Assistant to no one. There is no full professor in charge of the subject.
Q. Are you connected with Professor Chandler?
A. I have been his private assistant for the past ten years, and hold that position at the present time to Professor Chandler.
Q. Where were you educated Professor Metzger?
A. I received the degree of Ph.B. at Buchtel College, after a four years' course. The three years immediately following were spent, one year each at the University of Pennsylvania, at Yale and at Columbia, receiving the degree of Ph.D. at Columbia in 1902.
Q. Have you been connected since 1902 with the Department of Chemistry in Columbia?
A. I have.
Q. In 1906 were you put in charge of any particular department in Columbia?
A. It was in 1906 or 1907 that I was made head of the Analytical Department.
Q. And you now hold that position?
A. Yes, sir.
Q. What experience have you had, Professor Metzger in analytical investgations?
A. I have been continuously engaged during the past ten years in original investigations and analytical methods, and have published numerous articles in scientific journals on new methods of analyses as applied to various substances.
Q. In that way you have contributed, have you, to the literature of your profession?
A. I have.

1861 Q. Now, what experience have you had in industrial investigations?
A. I have been engaged from time to time in all manner of commercial problems.
Q. Patents?

A. Patents, new processes and so on.

Q. Have you had any professional connection with the Metropolitan Sewerage Commission of this city or this State?

A. I have been retained to investigate special chemical problems by that commission, as they arose, from time to time.

Q. Did you do original work for the commission, taking the oxygen determinations; what work did you do for the Metropolitan Sewerage Commission in that particular field?

A. I investigated the methods for the determination of oxygen.

Q. What methods did you consider?

A. The socalled Levy method was the method upon which most of the work was done. In that connection I made special studies with the method, with the object of making the method practicable for field work, incidentally introducing a slight modification of the original socalled Levy method.

Q. Was that modification for the convenience of field workers?

A. It was; it was to shorten the time required for an analysis, so that a larger number of analyses could be made in the same length of time.

Q. Did you prescribe how the samples should be secured, and with what special apparatus?

Mr. Riker: I object to it as immaterial and irrelevant.

The Commissioner: Note the objection.

A. The apparatus used was specially constructed to meet the requirements of the field work.

Q. What was the object in devising an apparatus to obtain samples at special depths, or in any special manner. Just tell us, Professor, all about those things?

A. The object is to secure the sample in such a way that there can be no action of the air before the analysis is made. In other words, to secure the sample that will represent the exact oxygen content of the water to be analyzed.

1862 Q. In devising such an apparatus, is it desirable to secure the sample and exclude the possibility of contact with the air until after you have made your determinations?

A. The method itself requires that all air should be excluded during the analysis, otherwise there would be contamination, and no true result of the amount of oxygen originally contained in the water could be obtained.

Q. You stated that you prescribed a modified form of the socalled Levy method. Will you describe that method with its modification and why the modification was introduced, and why that method was especially selected.

Mr. Riker: I object to it on the ground that it is immaterial and irrelevant.

The Commissioner: Note the objection.

Q. Giving the apparatus the solutions the method itself in detail?

A. The principle of the method depends upon the fact that fer-

reous iron in alkaline solution is readily oxidized by the oxygen dissolved in the water. Working, therefore, with the known amount of ferreous iron, in determining the excess of the ferreous iron, after the reaction, we obtain the correct amount of oxygen, which was contained in the water. The apparatus used, of which I have a drawing here, consists of a specially constructed separatory funnel (referring to drawing). B, the large bulb, has a capacity, roughly, of about 400 cubic centimeters. The small bulb, C, has a capacity of something more than 10 cubic centimeters with the ground stopper A, a stop cock as shown in the figure.

Q. Does this drawing that you have produced here fairly represent in outline the apparatus that was used?

A. It does.

Q. Under your direction?

A. It does.

Mr. O'Sullivan: I offer that in evidence and ask that it be marked Complainants' Exhibit No. 124.

Cross-examination by Mr. Riker:

Q. Who made this drawing?

A. That was drawn by Mr. Beans of the Drafting Department at Columbia University.

1863 Q. What scale was it drawn to?

A. I could not say; I should see the original. Probably one third, just a rough guess. The capacity would indicate that, that is, considering that the bulb B has a capacity roughly of 400 cubic centimeters, that would determine the scale to which that has been drawn.

Q. Does this contain the modification that you have described?

A. The modification is in the chemicals used, not in the apparatus.

Q. There is nothing new about this apparatus then?

A. Not necessarily, no, a few little points that we learned in our early investigations. For instance the stopper A in the first ones we had made was square at the end, and we found that that did not properly exclude air bubbles in inserting the stopper, so we had those made pointed, tapered as shown there. That allowed us to insert the stopper without including any air bubbles in on top.

Q. That represents the relative sizes of the different parts?

A. Yes, I should say so.

Mr. Riker: No objection.

The Commissioner: Received and marked Complainants' Exhibit No. 124.

Marked Complainants' Exhibit No. 124.

Direct examination by Mr. O'Sullivan (resumed):

Q. Have you fully described the apparatus now?

A. I think so.

Q. Now, as to the solutions employed, will you state the different solutions used, how they were used and why they were used?

A. We used a solution of potassium permanganate of such strength that one cubic centimeter is equivalent approximately to one cubic centimeter of oxygen at normal temperature and pressure. This permanganate solution, after being made up is very carefully standardized for the exact oxidizing value. We also used 10 cubic centimeters of sodium carbonate solution, a solution of ferreous sulphate, about 40 grams to the litre. This ferreous sulphate has added to it a little sulphuric acid to prevent hydrolysis of the iron.

Q. Professor Metzger, will you define what you mean by the term "hydrolysis"?

1864 A. Hydrolysis is the action of water in this particular case on ferric iron, thereby forming hydroxide precipitate.

Q. And to obviate that, what is done?

A. Sulphuric acid is added to maintain a clear solution.

Q. Have you given us all the solutions used in the so-called Levy method?

A. Yes, except that I did not mention with the addition of a solution of equal volumes of culphuric acid and water.

Q. Now, as to the method itself, will you describe how it is employed, and what results are expected?

A. The analysis is carried out as follows:

The separatory funnel which I have just described, having been filled with a sample of water to be analyzed, stopped A is removed and four cubic centimeters of the sodium carbonate solution is introduced by means of a graduated pipette, delivering the solution near the bottom of the bulb B. Next, we add 6 cubic centimeters of the ferreous sulphate solution, by means of a similar pipette, also delivering this solution near the bottom of the bulb B. Stopper A is then removed, and the apparatus rotated, or agitated in such a way as to produce a uniform mixture of the re-agents inside. After standing some minutes the apparatus is inverted and 10 cubic centimeters of a solution of equal parts of concentrated sulphuric acid and water are introduced into the small bulb C. By opening the stop cock, this acid, on account of its greater specific gravity diffuses through the mass, and acidifies the contents of the bulb B. When the precipitate, which originally formed in B, is dissolved, the contents of the flask are transferred to a suitable vessel and titrated with the standard solution of potassium permanganate. From these readings the amount of oxygen which was contained in the water is calculated. At the same time, what is commonly called a blank experiment, is made on a sample of water collected under the same conditions, is put through the same entire process, omitting, however, the introduction of sodium carbonate. This serves as our blank experiment, and establishes the standard or strength of the ferreous sulphate introduced. This blank determination is made with each analysis, taking into account the difference between

1865 the blank and the regular analysis, we calculate the amount of oxygen in the water.

Q. Have you now described the so called Levy method for oxygen determination?

A. I have.

Q. Have you made any analysis of gases emanating from the harbor waters?

A. I have.

Q. Will you describe the method you employed in collecting these gases and what chemical analyses or examinations you subjected them to?

A. The apparatus used in collecting the gases consisted of a large demijohn, or other suitable vessel, into the neck of which was fastened a large funnel. The demijohn was completely filled with water, then inverted under the surface of the water, and the gases allowed to pass up through the funnel into the bottle, replacing the water by downward displacement. When a sufficient quantity of gas had been collected, the funnel was removed and the bottle carefully sealed under water. These were then transferred to the laboratory for analysis.

Q. What methods did you employ in the laboratory in determining the composition of these gases?

A. Employed the usual method of gas analysis, using what is known as the Hempel apparatus. This apparatus is so constructed that a measured volume of the gas can be brought successively into contact with various absorbing solutions to remove one constituent after another from the gas mixture. The regular method of analysis consists in first removing the carbon dioxide present by means of a strong solution of caustic potash. Second, the removal of the oxygen by means of an alkaline solution of pyrogallic acid; then absorbing any carbon monoxide present by means of a solution of cuprous chloride. The remaining gases which may consist of marsh gas, hydrogen and nitrogen, is taken in part, or as a whole diluted with air, and the mixture exploded. By this process marsh gas is burned to carbon dioxide, the hydrogen burns to water; the nitrogen remains unaffected. By measuring the carbon dioxide formed the marsh gas can be calculated, and by noticing, or by noting the shrinkage in gas volumes, the hydrogen is calculated, and the sum of all the constituents thus far determined substracted from 100 gives us the nitrogen for the difference.

1866 Q. After employing these methods and collecting the gas samples emanating from the harbor waters in the manner that you have described, did you furnish any report on these gas analyses to the Metropolitan Sewerage Commission?

A. I did.

Q. How many reports?

A. I have before me carbon copies of reports of 10 such analyses.

Q. Made by you?

A. 7 of them were made by me personally, and 3 others by my associate, Professor Whittaker.

Mr. O'Sullivan: I offer in evidence the reports made by this witness to the Metropolitan Commission under date of August 15th,

1911, the other dated November 3rd, 1911, and ask that they be marked respectively Complainants' Exhibits Nos. 125 and 126.

Cross-examination by Mr. Riker:

Q. Doctor, this sheet which has the date August 15th, 1911, that is a carbon copy, is it not?
A. A carbon copy of the original, yes, sir.
Q. Made under your direction and supervision, the copy?
A. I do not believe it was; no, sir.
Q. Do you know where the original is?
A. I can find it in my notes, probably, at the laboratory.
Q. It represents work done by you yourself?
A. No, sir, not those three. The apparatus for the collecting and all the preliminaries were done by myself.
Q. Did you take the samples?
A. Our assistant took them yes, sir.
Q. I asked you whether you did?
A. No, sir.

Mr. Riker: I object to the offer of those papers, that paper of August 15th, 1911, on the ground that it does not appear to contain the results of work of this witness, and does not appear to contain any matter over which he has personal knowledge; also on the ground that it is immaterial and irrelevant.

Direct examination by Mr. O'Sullivan (resumed):

Q. Where was the typewriting done on that report of August 15th?
A. It was done in our office.
1867 Q. Where is that?
A. Columbia University.
Q. Has it ever been out of your possession?
A. This copy?
Q. Yes.
A. No, sir.
Q. The three samples that were analyzed other than by yourself, were analyzed by whom?
A. By Professor Whittaker, my associate.
Q. You are associated with Professor Whittaker?
A. I am.
Q. And this represents work done jointly by you and him?
A. I had no hand in the analysis personally.

Mr. O'Sullivan: I will withdraw the one of August 15th, as you did not do the work.

Cross-examination by Mr. Riker:

Q. Doctor, I ask you with reference to the yellow sheet which has date at the head November 3rd, 1911?
A. Yes, sir.

Q. Addressed to Dr. Soper?
A. Yes, sir.
Q. That is a carbon copy of some original paper?
A. I should say so, yes, sir; I should say that because we always make our carbons on yellow paper.
Q. You never compared it I assume?
A. I always compare all the results of analyses.
Q. I ask you as to the yellow sheet, that carbon copy, you did not compare it with the original of course, did you?
A. No, sir; I do not think I did.
Q. You assume, however, that that was made on a typewriter and that is a copy of the paper that you mean?
A. I do.
Q. That is all you know in regard to that paper?
A. Yes, sir.
Q. Where is the original?
A. The original copy, I should say, it was in Dr. Soper's hands.
Q. And who is Dr. Soper?
A. President of the Metropolitan Sewerage Commission.
Q. Do you know whether or not that is a board organized under the Laws of the State of New York?
A. I do not.
Q. You know it has an existence in this State, however?
A. Yes, sir.
1868 Q. It is operating here?
A. Yes, sir.
Q. And attached to that sheet there, there appear to be several white sheets, four in all; are those original papers?
A. No, sir; those are carbon copies. The originals are presumably in the hands of Dr. Soper.
Q. So far as you know, they are attached to the original letter which you signed and sent to him?
A. Yes, sir.
Q. And the original embodies the results of work done by you personally?
A. Yes, sir.
Q. Now, did you take any of the samples that you analyzed personally?
A. No, sir. Some of those were collected by our assistant Mr. Durkee.
Q. Were you present?
A. No, sir.
Q. How do you know that they were collected by your assistant, Mr. Durkee?
A. Because I sent him out with the apparatus, and he brought it back with the samples.
Q. You took it for granted that he did what you told him to do?
A. Yes.
Q. And did it at the place you said to do it?
A. Yes, sir.

Q. And that is all you know about it?

A. Yes.

Q. Have you not original memoranda of the analyses that you have?

A. I have them with me.

(Witness produces original notes.)

Mr. Riker: I object to the offer on the ground that it is not an exhibit properly in the cause, and that it can only be used to refresh the witness' memory as to the result of matters he had personal knowledge of, and the best memoranda for that purpose are the original ones made by him at the time.

Mr. O'Sullivan: Do I understand, Mr. Riker, that you insist upon my offering his original memoranda in pencil, made by him in his laboratory and part of his laboratory memoranda, as an exhibit?

Mr. Riker: No. That would not be a correct statement of my point. My point is that while they are not exhibits at all and none of them ought to be offered, and all this witness can do is to refresh his memory as to matters that he had personal knowledge of, and for that purpose he can testify from the memoranda, and
1869 they should not be offered as exhibits and are not exhibits in the cause.

Direct examination by Mr. O'Sullivan (resumed):

Q. Mr. Metzger, will you please state what report you made, what analyses you made, and the results of those you reported?

A. November 3rd, 1911, I reported results of analyses of waters to Doctor G. A. Soper as follows (referring to original notes):

Analysis of Samples of River Gas for Dr. Geo. A. Soper, Metropolitan Sewerage Commission, New York.

Sample #111,030.

Marked "E. 109th St., Harlem."

Date 10-31-'11.

Carbon Dioxide	4.2%
Oxygen	0.4%
Methane	86.7%
Hydrogen	None
Carbon Monoxide	None
Nitrogen (by diff.)	8.7

Sample #111,034.

Marked "Foot Broadway, Astoria."

Date 10-31-'11.

Carbon Dioxide	11.5%
Oxygen	0.4%
Methane	84.8%
Hydrogen	None
Carbon Monoxide	None
Nitrogen (by diff.)	3.3%

Sample #11113.

Marked "#1."

Delivered by Dr. Parsons Nov. 2, 1911.

	Carbon Dioxide	9.8%
1870	Carbon Dioxide	7.6%
	Oxygen	0.2%
Methane		85.4%
Hydrogen		None
Carbon Monoxide		None
Nitrogen (by diff.)		6.8%

Sample #111,031.

Marked "E. of De Graw St."

Date 10-31-'11.

Carbon Dioxide	1.8%
Oxygen	2.4%
Methane	82.1%
Hydrogen	None
Carbon Monoxide	None
Nitrogen (by diff.)	13.7%

Sample #111,032.

Marked "E. 24th St."

Date 10-31-'11.

Carbon Dioxide	2.4%
Oxygen	1.3%
Methane	83.3%
Hydrogen	None
Carbon Monoxide	None
Nitrogen (by diff.)	13.0%

Sample #111,033.

Marked "Wallabout Canal."

Date 10-31-'11.

Oxygen	1.1%
Methane	83.7%
Hydrogen	None
Carbon Monoxide	None
Nitrogen (by diff.)	5.4%

Sample #11114.

Marked "#2."

Delivered by Dr. Parsons Nov. 2, '11.

Carbon Dioxide	1.2%
Oxygen	1.0%
Methane	88.1%
Hydrogen	None
Carbon Monoxide	None
Nitrogen (by diff.)	9.7%

Q. In addition to the original work that you have just described and which you did for the Metropolitan Sewerage Commission of New York, did you do any supervisory work?

A. I did. I have accompanied Dr. Parsons on the boat.

Q. First, in line with that supervisory work, I want to know if you prepared and standardized solutions for the use of that commission, and if so, state what you did in that respect?

A. I prepared all of the standard solutions employed in this work, made the solutions myself and standardized them.

Q. For whose use?

A. For the use of the Metropolitan Sewerage Commission. I also calibrated flasks to determine their exact capacity.

Q. Tell us what calibrating a flask means?

A. Calibrating a flask means the determination of the exact capacity of the flask.

Q. Now, what else did you do besides preparing and standardizing solutions and calibrating flasks; did you calibrate any other implement or apparatus besides these flasks?

A. I recall testing hydrometers for Dr. Soper.

Q. You went on to state that you were going with somebody making these determinations?

1872 A. I have also accompanied Dr. Parsons in the boat, watched him make the analyses, seen that the methods were being properly carried out, also making analyses myself on such occasions.

Q. Were these analyses in the nature of check experiments or determinations?

A. They were.

Q. With what results as compared with Dr. Parsons' determinations?

A. To establish the accuracy of his work.

Q. What results flowed from this, how did you find his work?

A. I found his work perfectly satisfactory.

Q. I will put the question again to you, it may have been satisfactory to you, but the question asked was, whether it was accurate or not?

A. The results of Dr. Parsons' work were accurate.

Q. Now, did you conduct any independent set of check experiments or determinations paralleling the determinations of Dr. Parsons, and if so, state why, and with what results?

A. I did. On July 25th, 1911, I accompanied Dr. Parsons on the boat.

Mr. Riker: What are you using there?

The Witness: The carbon copy of a report.

Mr. Riker: It appearing that the witness is using the paper which is merely a copy of something which has not yet been disclosed, I object to the testimony.

The Commissioner: Note the objection.

Mr. Riker: Where is the original, was it sent to Dr. Soper?

The Witness: Yes.

Q. Dr. Metzger, the paper that you have now before you, has that ever been out of your possession?

A. It has not.

Q. What does it purport to be?

A. It is a carbon copy of my report to Dr. Soper.

Q. On what?

A. On the determination of dissolved oxygen in water, made by myself.

Cross-examination by Mr. Riker:

Q. Upon what was that report based; original memoranda made at the time?

A. The memoranda were made on the boat when the analy-
1873 ses were made. They were also entered, as I recall it, by Dr. Parsons. Dr. Parsons made no analyses on that day.

Q. Where are those original memoranda?

A. His field books will probably show the original.

Q. Those entries in his field books were made under your supervision?

A. They were my analyses. Those would constitute the original memoranda.

Q. Did you have those before you when you wrote this report?

A. I did.

Q. This paper which you have before you is not a copy of this memoranda?
A. No, sir.

Mr. Riker: I object to the use of the paper.
The Commissioner: Note the objection.

Direct examination by Mr. O'Sullivan (resumed):

Q. Is it a tabulation based on field notes from which you took it?
A. It is.

Mr. O'Sullivan: Counsel for Complainants desires to call to the notice of Counsel for the Defendants that these field note books were produced when Dr. Parsons was on the stand and were presented to Counsel for the Defense for the purpose of conducting cross examination.

By Mr. O'Sullivan:

Q. You may answer my question, Doctor?
A. I accompanied Dr. Parsons on the boat, making determinations of oxygen, upon the Hudson River from the Battery to a point a little above Yonkers, a total of 18 determinations. The results of these analyses I have before me.
Q. Can you state what the results were, Doctor?

Mr. Riker: The same objection.
The Commissioner: Note the objection.
Mr. O'Sullivan: You object to what?
Mr. Riker: I am simply objecting to the use of this as memoranda to refresh his memory.
The Commissioner: Note the objection.

Q. Proceed, Doctor?
A. The following figures are the results of my own personal analyses of oxygen determinations from Pier A to a point
1874 a little above Yonkers, July 25th, 1911.

Analyses Made July 25th, 1911.

C. C. Oxygen, Per Liter.

Location.	Surface	Bottom
Midway between Pier A and C. R. R. of N. J. Ferry	3.00	3.00
Midstream off W. 23d St.	3.01	2.80
" " " 42d "	2.86	2.86
" " " 72d "	3.29	3.15
" " " 129th "	4.00	3.86
" off Ft. Washington Pt.	4.24	3.70
" " Spuyten Duyvil Creek	4.43	3.86
" " Mt. St. Vincent	4.94	4.66
" 1000 Ft. North of Power House Yonkers	5.44	5.29

Q. Doctor, from the supervisory work which you have just described, from the preparation and standardization of the solutions, calibrating the flasks, and other apparatus, and the parallel determinations you yourself made as check experiments upon the work of Dr. Parsons, what do you say as to the accuracy and reliability of the oxygen determinations made by Dr. Parsons?

Mr. Riker: I object to that question for the reason that the only thing this witness can testify to is the correctness of those observations which he himself has compared and checked, and that he cannot testify as to any other, because he has no knowledge upon which to base his testimony, and this is a mere opinion, as to which he is not qualified to guess, to guess as to matters of which he has no knowledge.

The Commissioner: Note the objection.

A. From my observations, Dr. Parsons' work, his use of the method of analysis, his accuracy in manipulation; from the fact that I personally prepared all the standard solutions, and from time to
1875 time made check analyses with Dr. Parsons. I consider Dr. Parsons' work reliable and accurate.

Mr. O'Sullivan: Your witness.

Cross-examination by Mr. Riker:

Q. Doctor, you have quite a number of ifs and assumptions in this last answer of yours, have you not?

A. Opinions based on my observations.

Q. You assume that if he used the methods in all cases that you directed, and if he used the apparatus that you furnished, and if he complied with your instructions in every way, as he did on the occasion when you noticed him, then in your opinion, the results are accurate, is not that it? Do not I make myself clear?

A. Yes, sir.

Q. Cannot you answer the question?

A. (No answer).

Q. Do not you want to answer the question?

A. No, sir.

Q. Are you going to answer it?

A. I will.

Q. All right, what is the answer?

(Question repeated by the stenographer.)

A. It is.

Q. How many determinations do you know that Dr. Parsons has made in this investigation?

A. I have seen the tabulated results, but could not state with any degree of accuracy the total number. I have not counted them.

Q. How many of them did you check up yourself personally?

A. I checked up in connection with Dr. Parsons in my own private laboratory at the beginning of the work, where we analyzed waters taken from the laboratory, quite a large number of samples, to instruct Dr. Parsons in the manipulative detail of the method.

These investigations were carried on until I was completely satisfied that Dr. Parsons could handle the work perfectly satisfactorily.

Q. They were in the nature of tests, were they?

A. They were.

Q. Of the determinations made by him for the records of the Metropolitan Sewerage Commissioners, how many did you actually check up yourself?

A. I have just referred to a series of eighteen, which I presume are in the official records.

1876 Q. Did Dr. Parsons make coincident determinations?

A. He did not on that day.

Q. You made the only ones that were made?

A. I did, on that day.

Q. You would not call these check observations, would you?

A. Except in a general way, that they gave the same general results as Dr. Parsons had been getting in that section of the river under similar conditions.

Q. How do you know the conditions were similar?

A. Conditions as to tides as I understood and winds, and so on.

Q. Those conditions were observed, were they observed by you at all?

A. No, sir. I was not to judge of that matter. That was a question for Dr. Soper. I was asked to make those determinations to see whether I would get the same general results as Dr. Parsons had been getting.

Q. Do you, in your professorial capacity, call those observations check observations?

A. I should say they are, in a general way: The only absolute check observations that could be made would be by taking identical samples and analyzing them.

Q. Is not that what you would call a check observation properly speaking?

A. Not necessarily.

Q. These are what you call generally check observations?

A. Yes.

Q. The ones that you made?

A. Yes.

Q. Now, in the determinations of oxygen under the Levy method—is there anything new about that?

A. The modification which I introduced into the method was the use of sodium carbonate solution instead of ammonia solution, previously used.

Q. And that modification was in the line of expedition rather than accuracy, was it not?

A. It was.

Q. As to the accuracy, which, in your judgment is the more accurate method?

A. There is no difference I compared them in a large number of samples before we adopted the modification.

Q. So the modification did not add any to the accuracy of that process?

A. No, sir.

1877 Q. Is the Levy method a recognized method, adopted generally in the determination of the oxygen contents of water?

A. It is.

Q. And the Hempel method of determining the gas content of your sample in flasks, is that a standard method?

A. It is.

Q. It has been known for a good while?

A. It has.

Q. And applied generally?

A. It has. We used it year after year in the laboratory for students.

Q. There is nothing unusual about that?

A. No.

Q. Now, these samples which you analyzed under the Hempel method, were they taken by you, the samples?

A. No, sir.

Q. Were they taken under your directions?

A. They were not.

Q. You did not even fix the place where they were to be taken?

A. I did not.

Q. You do not know anything about it except that the vessels came to you and you made the determinations?

A. No, sir.

Direct-examination by Mr. O'Sullivan (resumed):

Q. Who brought those vessels to you, Professor Metzger?

A. Dr. Parsons.

Q. Had he received directions how to collect those gases?

A. He had. He had been into my office several times previous to the collection of these samples, and a general scheme was decided upon, and the samples collected in accordance with that general scheme.

Q. And the samples so collected were brought to you?

A. They were.

Q. And analyzed by you?

A. They were.

Q. With the results which you have already testified to?

A. Yes, sir.

Cross-examination by Mr. Riker:

Q. Doctor, when you say they were collected in that way; do you know of your own knowledge whether they were or not?

A. No, sir.

Q. You believe it, that is all there is to that?

A. Yes sir,

Mr. O'Sullivan: That is all Doctor.

1878 EMIL KUICHLING, a witness called on behalf of Complainants, being first duly sworn, testified as follows:

Direct examination by Mr. O'Sullivan:

Q. Mr. Kuichling, what is your profession or vocation?

A. Civil Engineer; more particularly hydraulic and sanitary engineer.

Q. Where do you reside?

A. In the City of New York at the present time.

Q. And where is your office address?

A. Office address 52 Broadway.

Q. Will you state where you got your college education?

A. My college education was received in the University of Rochester, New York, graduating as A.B. in 1868; same Post Graduate Scientific Course, 1869, Degree C.E.; Polytechnic School of Carlsruhe, Germany, Course in Civil Engineering, 1870-1872 (3 years), Certificate C.E.

Q. Now, taking your preliminary practical work from 1863 to 1870?

A. From 1863 to 1870 was employed during vacations in various subordinate capacities in the City Engineer's Office, Rochester, N. Y., and the Engineer's Office of the New York State Canals. This gave experience in surveying, office work, drawing and construction; it also showed me the necessity for further study and observation of works by travel.

Q. What work did you do during that period, what type of work?

A. The type of work done was field surveys and tracings of maps, and structures, in some cases tracings of my own designs for such structures; and computations for structures and for surveys. Surveys, computations of areas, and the computations for latitude and departure; that would be arithmetical work essentially.

Q. Now, from 1873 to 1885, what line of work were you engaged in?

A. From 1873 to 1885, was employed as assistant and principal assistant engineer on the construction and operation of the Rochester (N. Y.) Water Works, and in 1881 was appointed engineer for the New York State Board of Health. This latter work occurring only occasionally, I received leave of absence from the City Department so that I might perform this occasional work for the State Board of Health.

1879 Q. During this period did you come in contact with the problems of sanitary engineering?

A. I did.

Q. What does that mean?

A. Sanitary engineering in the early days of the science or art was house drainage, the disposal of house wastes, sewerage of municipalities, and the disposal of sewage. The study of bacteriology which had just begun to be introduced in the early 80's and the study of disease such as would affect public health generally, malarial diseases, contagious diseases, and methods of preventing the spread of diseases. Also the drainage of lands for the removal of malaria.

Q. Without going into further detail would you group those under the term "public hygiene"?

A. Yes, this would all come under the head of Public Hygiene.

Q. And did that engage your study during that period?

A. It did.

Q. Will you state some of the important problems that were brought before the Board at the time of your connection with it, during the years just stated?

A. The most important problem brought before said Board at this time was the project of the new Croton Dam and Reservoir, involving the principles of water storage, the sanitary protection of water sheds, and the cleaning of aqueducts following construction; also the drainage of extensive swamps (Oak Orchard and Montezuma) and the channels of the abandoned State Canals. That area which is between the foot of Seneca Lake and Cayuga Lake particularly, and extends along the lines of the Seneca River for many miles. It is one of the largest problems that the State of New York had. It is similar to the problem of the betterment of the Florida swamp region and the Virginia swamp region.

Q. About that time that the State was engaged in utilizing the channels of the abandoned state canals?

A. Yes, sir.

Q. Did they come under your purview at the time?

A. Yes, sir. Many of the lateral canals tributary to the Erie Canal had been abandoned by the State by legislative act, and in many cases these abandoned channels became malarial. They
1880 developed extensive sickness in certain regions through which they passed. It was my business to secure drainage for these canal channels, which had been abandoned.

Q. Now, taking the problems that you have just discussed that confronted the State Department and the Health Department during your connection with it in the years that you have testified to, did you have to take up a special line of study on that subject to equip yourself?

A. I did.

Q. State what it was?

A. It was the study of malarial bacteria, which had been begun to be suspected as being the cause of great epidemics, the spread of epidemics in popular communities, as well as over the country region. That line of study was called Epidemiology, and in connection with this was also the study of the fundamental elements of protozoa.

Q. Did you go abroad?

A. Yes. There was no literature of any consequence available in our own country, and that of Great Britain was very meagre. I found that much of the work was being done in France and Germany, and that English and American authors were copying these works. The first work, I believe, that was published on bacteriology in this country was I think in about 1880 or 1881, and was a translation by Dr. George M. Sternberg, then connected with the United States Army Corps, the translation of the work by a French hygien-

ist, Dr. Magnin. That was a small book, about half an inch thick at that time. Dr. Sternberg's newest publication on bacteriology, I think, constitutes two volumes, great octavo, each about 2½ or 3 inches thick. I merely mention this to indicate the growth.

Q. Without going into the details of that, you found out that the literature they had in America was translations or abstracts from work done by eminent men in France and Germany, is that it?

A. Yes, sir.

Q. Did you take up your studies in either of those countries?

A. Then I went abroad in 1883 to study the subject at first hand in both England, France, and Germany. In this way, as the accredited engineer of the New York State Board of Health, I went abroad to the different hygienic laboratories and the various Health Boards,
both Municipal and State, Departmental Boards of England,
1881 France, and Germany, and I learned their methods, read
their reports, and saw their experiments and experiment stations, made notes of all these features with a view of establishing a similar experiment station in the State of New York, and made a report of this to the State Board of Health.

Q. Now, on returning to this country, what did you do and when did you return?

A. The first use I made of this was on returning in the early summer of 1884. That was the formulation of a set of rules for the sanitary protection of the water supply of the City of Rochester, New York. This was the first time that such a system of rules was formulated and it has served as a general formula to be followed by authorities in this country and abroad since. The original has been somewhat modified. These rules were adopted, as I say, with a few modifications elsewhere. The fundamental purpose of this was finally to formulate similar rules for the protection of the Croton water sheds, but as the work then was for the new water supplies for the City of New York, which were in progress, this was deferred till some years later, but meanwhile the principles were applied to the water sheds of the smaller communities in the State of New York.

Q. Now, we have got as far as the year 1885. Did you hold any position in the City of Rochester?

A. In 1885 I was elected a member of the executive board of the City of Rochester, N. Y., for the term of three years. This Board consisted of three members and had entire charge of the construction and maintenance of all public works and the Fire Department. At the close of my term of office, I was employed by the City to prepare plans for the comprehensive sewerage of the eastern half of the municipal area, and was engaged in this work until May, 1889.

Q. Were there any collateral studies?

A. Many collateral studies were involved therein, such as the relation of rainfall to runoff, the characteristics of the Genesee River and Lake Ontario, and the purification and disposal of sewage by various methods. On completing said plans, I again went to Europe on a tour of observation and study, returning in the autumn of 1889, when I was employed as an Assistant Engineer in the design and

construction of the works for the water supply of the city of
1882 of Newark, N. J., by the East Jersey Water Co. Remained in this employment until September 1, 1890, when I returned to Rochester, N. Y., to take charge of the Water Works as Chief Engineer and Superintendent.

Q. That brings us up to 1890. Now, from 1890 to 1900?

A. During this period, from 1890 to January 1st, 1900, I remained in charge of the Rochester Water Works and designed and built the works for a new and much larger supply of water for that city. This work was finished about 1895.

Q. And it began when?

A. It began in 1892. Preliminary study for this new supply began immediately on my arrival there in Rochester in September, 1890, when I left the employ of the East Jersey Water Company.

Q. When did you resign, and from what position with the New York State Board of Health, as it was known at that time?

A. In 1893, I resigned as Consulting Engineer of the New York State Board of Health, as my time was then fully occupied with my other duties. During the period from 1881 to 1893, however, I had made many experiments and reports to said Board of sanitary conditions as to the sewage and water supply of numerous villages and small cities and state institutions, the greater number of these reports being published in the Annual Report of the Board, and in addition thereto I did much private work as Consulting Engineer and as Assistant to other Engineers.

Q. Give me some of them?

A. Among the water works I designed and built were: Water works built for Fredonia, N. Y., 1883; Geneseo, N. Y., 1887; extensions for Ithaca, N. Y., 1890-9; Atlantic City, N. J.; Geneva, N. Y.; Craig Colony, N. Y., water supply projected for Syracuse, N. Y., 1889; Pittsburg, Pa., 1899.

Q. Now, coming to the sewerage system, what experience have you had on that?

A. In addition to what I had in the City of Rochester for many years as a young man, and later on as Commissioner of Public Works, and as Engineer, I designed the sewerage plant for the City of West Toronto, Ontario, in 1890.

1883 Q. In Canada?

A. Yes, sir. In the City of North Tonawanda, New York, 1890; Oneida, New York, 1892; Clinton, New York, 1892; Batavia, New York, 1893; Craig Colony, New York, 1891 or 1892.

Q. Have you had any experience in water power developments?

A. Yes, sir. I have had extensive experience in that. I had that on the Genesee River in Rochester, New York, where we had three falls, two of nearly 100 feet in height each, and then an intermediate one of some 30 feet, together with some rapids, giving power of 20 to 22 feet head. While with Mr. Herschel, I made preliminary plans for the Water Power Development at Niagara Falls.

Q. What years?

A. The year 1889, and then at other times I was connected with the Niagara Power Developments by other companies up to the year

1896. I also examined and made reports on water power on Yadkin River, North Carolina, in 1899, and on the Genesee River in New York State, in various parts, and I made a number of reports and examinations at various times from 1880 to 1896.

Q. Have you had any experience in railroad construction and valuation? I do not want you to go into details?

A. Yes, I had to do with both the construction and valuation of railroad work on the New York, Lackawanna & Western Railroad in 1882, about; valuations of the Ithaca, Cortlandt & Northern Railroad in 1891; Western New York and Pennsylvania Railroad in 1882 or 1883; grade crossings cases at Buffalo in 1883, and a number of others.

Q. Have you had any professional connection with the Barge Canal, which is now nearly completed, and if so, state what?

A. Yes, sir. In 1900 for about a year I was employed by the State Engineer of the State of New York to make surveys and plans for the water supply of the proposed Barge Canal, which is now nearly completed. My report on this work is contained in the special Report of the State Engineer on the Barge Canal, Albany, 1901. In this report is contained all the data then available relating to the flow of streams and the rainfall on their drainage areas, to-
1884 gether with methods of computing water storage, and the consumption of water by canals.

Q. That is now a state publication?

A. Yes, sir.

Q. Since 1901?

A. Since 1901 I have been in private practice as a Consulting Engineer in the City of New York, and have been engaged on work as follows——

Q. On sewerage systems?

A. Yes. Sewerage systems at Batavia, New York, Atlantic City,

A. Yes. Sewage systems at Batavia, New York, Atlantic City, New Jersey, Jersey City, New Jersey, Cumberland, Maryland, Rochester, New York, Back Bay District of Boston, Massachusetts.

Q. What water supply systems have you been engaged on?

A. Water supply at Perth Amboy, New Jersey, Jersey City, New Jersey; Pennsylvania Water Company; Medina, New York; Norfolk, Virginia, Utica, New York, Seneca Falls, New York; New York Custodial Asylum; San Juan, Porto Rico, Charleston, South Carolina, and a number of others that I do not recall now.

Q. Have you had professional calls to make water works valuations?

A. Yes, sir; I have made valuations of water works plants and property at Ithaca, New York, Pennsylvania Water Co.; Spot Pond, Boston, Massachusetts; Brookport and Holley, New York; Ephrata, Pennsylvania, Massillon, Ohio, and Delaware, Ohio.

Q. Have you been professionally engaged in the development of water power in any of our rivers?

A. I have. I have been active in the development of water power on the Catawba River, South Carolina; Yadkin River, North Carolina; Potomac River, Virginia, Occoquan River, Virginia; James

River, Virginia; French Broad River, North Carolina; Ivy River, North Carolina; Susquehanna River, Pennsylvania; Schuylkill River, Pennsylvania; Roanoke River, North Carolina and Virginia; St. Lawrence River, New York; Black River, New York; Great Egg Harbor River; New Jersey; in Porto Rico; on Feather River, California; on Des Chutes River, Oregon.

At 1 P. M. adjourned for Noon recess until 2 P. M.

1885 CORPORATION COUNSEL'S OFFICE,
NEW YORK, June 12th, 1912—2 p. m.

EMIL KUICHLING, a witness called on behalf of Complainants, recalled for further examination, testified as follows:

Direct examination by Mr. O'Sullivan (resumed):

Q. Have you had any problems to solve relative to water storage for the Barge Canal?

A. Yes, sir, I have had them to solve in a number of places in the State of New York. The storage reservoirs for the Barge Canal are the West Canada Creek, on the Mohawk River and the betterment, enlargement of some of the older reservoirs of the Erie Canal in the Central part of the State, all of which would become serviceable for the Barge Canal. I have also had storage to provide for several branches of the Feather River, California, on Adirondack Forest Preserve Association, New York; in watershed of Black River, New York.

Q. You have said something about railroad construction. You have had to do with railroad construction as an engineer?

A. Yes, sir. I *have* to do recently with the construction of a short branch railroad from the Southern Railroad line to Whitney, North Carolina. That is the latest one. I was on other railroads before.

Q. Have you been engaged as a professional witness in litigations in which engineering skill and knowledge were involved?

A. Yes, sir, in a large number of such. The first one was the City of Rochester vs. The Mill Owners on Honeoye Creek in 1884; Faulkner vs. McCurdy, Dansville, New York, 1880; Faulkner vs. New York Lake Erie & Western Railroad, 1885; New York Lake Erie & W. R. R. vs. N. Y. L. & W. R. R. 1882; City of Syracuse vs. Mill Owners on Skaneateles Outlet, 1894-1896; Gilbert et al. vs. N. Y. C. & H. R. R. R. at Little Falls, New York, 1899-1902; various parties vs. Utica Water Co., Utica, New York, 1902; Montgomery Water Power Co. vs. contractor for Dam, 1902; Steele Bros. vs. City of Gloversville, New York, 1904; Village of Fultonville, New York, to acquire water rights, 1901-2; Jersey City vs. Boroughs of Harrison and Kearney, N. J., 1902-4; Jersey City vs. Jersey City
1886 Water Supply Co. et al., 1905-1907; City of New York in various condemnation cases of Byram Pond, Cross River, East Branch of Croton River, and Croton Falls, and also in opposition to high assessment of various reservoirs, etc., 1906-1908. State

of New York vs. Fulton Light, Heat & Power Co. in Court of Claims, 1908-1909.

Q. Now recalling your several stays in Newark, what particular lines of study in relation to your profession did you pursue?

A. I took up and studied the principles and practice of water purification by filtration, water softening, sewage treatments of every description, irrigation and drainage. I have also visited many water works and sewerage plants in our own country during their construction and subsequently when in operation.

Q. Now, as to harbors and sewage disposal systems?

A. I studied that subject closely in the harbors of Boston, New York, New Rochelle, Philadelphia, Baltimore, Norfolk, London, Liverpool, Glasgow, Dublin, Dover, Southampton, Calais, Cherbourg, Amsterdam, Rotterdam, Antwerp, Hamburg, Bremen and Venice.

Q. I do not recall whether I asked you what societies you were connected with professionally?

A. I have been for many years a member of the American Society of Civil Engineers, American Water Works Association, New England Water Works Association, American Public Health Association, Rochester Academy of Science, Rochester Engineering Society.

In addition to the foregoing which relate to salt water harbors, I have studied the harbors of the large cities on the Great Lakes, especially Lake Ontario and Lake Erie and Lake Michigan, Rochester, Toronto, Ogdensburg, Kingston, Hamilton, on Lake Ontario; and Buffalo, Cleveland, Toledo, on Lake Erie also several smaller ones that I do not quite remember now, and the conditions at Chicago on Lake Michigan, Chicago, and Milwaukee.

Q. Mr. Kuichling, have you collected basic physical data relating to the Metropolitan and the Passaic Valley Sewerage District?

A. I have.

Q. What do you mean by the Metropolitan Sewerage District; what is comprehended by that term?

A. The Metropolitan Sewerage District of New York is an area including the City of Greater New York, portions of
1887 Nassau County on Long Island, portions of Westchester County north of the boundary line of the City of New York; also a large area of territory in the State of New Jersey. The Sewerage Commission has made the general boundary line dependent upon water shed lines in some cases, and in other cases more or less arbitrary in nature to show what in their opinion should be included in a Metropolitan Sewerage District for the City of New York. This is shown upon a certain map which I have in my hand and which I reduced in size from a much larger map which was furnished my by the Metropolitan Sewerage Commission of New York.

Q. Who prepared the map?

A. I prepared it myself with an assistant. I did a considerable portion of the work in my own hand; it is a mechanical reduction.

Q. And the rest of the work?

A. Was done by my assistant under my personal direction, more or less continuously, last September. The map is dated September

5th, 1911, and I think we were at work at it about a week or so in getting the thing into shape for presentation on a convenient scale.

Q. Taking the outline territory on that map, where is this sewage discharged; where does this run off go to?

A. It goes into the Hudson River, the East River, the Harlem River and into Long Island Sound, Jamaica Bay, Atlantic Ocean, and the upper Bay, for that portion of the territory in the state of New York. For that in the State of New Jersey, it goes into the Hudson River the Hackensack River, and tributaries, and the Passaic River and its tributaries; thence into Newark Bay; then into the Arthur Kill and the Kill van Kull; also into the Elizabeth River and Morse Creek, the Rahway River, Woodbridge Creek, and the Raritan River. Staten Island, or the Borough of Richmond, which is also in the State of New York, drains, first, into the Upper Bay, second the Lower Bay, third the Raritan Bay, fourth, the Arthur Kill, fifth, Newark Bay, Sixth, Arthur Kill, back again to the Upper Bay of New York.

Mr. O'Sullivan: In order that it may appear clear during 1888 our further allusions to the Metropolitan Sewerage District, I offer in evidence the map prepared by this gentleman as testified to, and ask that it be marked Complainants' Exhibit No. 125.

The Commissioner: Received and marked Complainants' Exhibit No. 125.

Marked Complainants' Exhibit No. 125.

Q. Now, will you give me the area of this Metropolitan Sewerage District of which you have furnished the map, and describe in general its shape and the other features connected with it, giving us such other data as you think would be necessary in this particular instance?

A. The Metropolitan Sewerage District, referring to the City of New York, embraces an actual area of 853 square miles of land, marsh and open water surface. Its shape is an irregular quadrilateral, having an average width from West to East of 27 miles, and an average length from South to North of 32 miles. Its corners are from 17 to 28 miles distant from the City Hall in the Borough of Manhattan. It includes the whole of the Passaic Valley Sewerage District, excepting an area of 4 or 5 sq. miles northeast of the City of Paterson, New Jersey.

Of this total area, about 524 square miles are in the State of New York and 329 square miles are in the State of New Jersey. In the following figures, the area of the principal smaller islands is included in the area of dry land surface.

	New York.	New Jersey.	Sum.
Total Dry Land surface, sq. miles.....	316.4	252.4	568.8
" Marsh " " "	38.9	42.8	81.7
" Open Water " " "	168.5	34.0	202.5
Total.....	523.8	329.2	853.0

Of the said 168.5 square miles of open water surface in the State of New York, 81.0 square miles are in lower New York Bay and the Atlantic Ocean adjacent to the Boroughs of Richmond, Brooklyn and Queens.

1889 The following table shows the respective areas of dry land, marsh and open water surface in the several major civil subdivisions of the Metropolitan Sewerage District:

Subdivision.	Dry Land Surface.	Marsh Surface.	Open Water Surface.	Total.
I. State of New York:				
Borough of Manhattan, sq. mi.	21.2	0.0	10.7	31.9
" " The Bronx, " "	36.1	5.6	16.7	58.4
" " Brooklyn, " "	55.7	10.7	49.3	115.7
" " Queens, " "	89.6	14.3	36.6	140.5
" " Richmond, " "	50.0	8.1	47.1	105.2
Total in City of New York, sq. mi.	252.6	38.7	160.4	451.7
Part of Westchester Co., sq. mi.	58.5	0.1	5.3	63.9
Part of Nassau Co., " "	5.3	0.1	2.8	8.2
Total in State of New York, sq. mi.	316.4	38.9	168.5	523.8
II. State of New Jersey:				
Part of Middlesex Co., sq. mi.	20.8	1.8	2.9	25.5
" " Union " " "	55.8	6.9	2.5	65.2
" " Essex " " "	58.9	7.2	2.8	68.9
Entire Hudson " " "	30.2	13.4	19.8	63.4
Part of Passaic " " "	29.6	0.0	0.8	30.4
" " Bergen " " "	57.1	13.5	5.2	75.8
Total in State of N. J., sq. mi.	252.4	42.8	34.0	329.2
Total in Entire District	568.8	81.7	202.5	853.0

The population in the Metropolitan Sewerage District as deduced from the U. S. Censuses of 1890, 1900 and 1910, and as estimated for the year 1940 by the Metropolitan Sewerage Commission and the Central Committee Experts for the State of New York, is as follows:

1890 Subdivision.	U. S. Census, 1890.	U. S. Census, 1900.	U. S. Census, 1910.	M. S. Com. & Central Com., 1940.
I. State of New York:				
Borough of Manhattan.....	1,441,216	1,850,093	2,331,542	3,600,000
" " The Bronx	88,908	200,507	430,980	1,200,000
" " Brooklyn	838,547	1,166,582	1,634,351	3,200,000
" " Queens	87,050	152,999	284,041	870,000
" " Richmond	51,693	67,021	85,969	130,000
Totals for City of New York	2,507,414	3,437,202	4,766,883	9,000,000
Part of Westchester Co.....	66,350	98,830	168,577	406,000
Part of Nassau Co.....	813	1,205	1,783	2,000
Totals for State of N. Y.	2,574,586	3,537,287	4,937,243	9,408,000
Decennial increase, per cent.	37.4%	39.4%	.....	24.0%
II. State of New Jersey:				
Part of Middlesex Co.....	[illegible]10	23,422	43,171	100,000
" " Union "	58,818	75,954	108,427	240,000
" " Essex "	252,455	348,278	501,102	930,000
Entire Hudson "	275,126	386,048	537,231	1,250,000
Part of Passaic "	96,376	143,469	200,921	507,000
" " Bergen "	28,163	51,069	96,435	330,000
Totals for State of N. J.	730,948	1,028,240	1,487,287	3,457,000
Decennial increase, per cent.	42.6%	44.7%	.....	32.2%
Totals for Entire District	3,256,534	4,565,477	6,424,530	12,846,500
Decennial increase, per cent.	38.4%	40.7%	.....	26.6%

The Passaic Valley Sewerage District embraces most of the watershed of the Passaic River from its mouth at the head of Newark Bay to the West line of the City of Paterson, New Jersey. It includes the cities of Newark, Passaic, Paterson and Orange, as well as many populous boroughs and villages. Its general outline is a par-
1891 allelogram about 17 miles long and 6 miles wide. About one-third of the area lies on the east side of the river.

According to the published report of the Passaic Valley Sewerage Commission, dated April 20, 1908, the district includes thirty communities, of which 19 are on the east side of the Passaic River and have an aggregate tributary drainage area of 34.1 square miles, while the remaining 11 communities are on the west side of the river and have an aggregate tributary drainage area of 69.1 square miles. The total area regarded as tributary to the proposed trunk sewer is thus 103.2 square miles. It should, however, be noted that in a number of cases only a part of the entire area of the municipality has been so included, and that the total area covered by the said thirty communities is 140 square miles. The entire watershed of the Passaic River above its mouth has an area of 949.1 square miles.

The Population in the Passaic Valley Sewerage District, as deduced from the United States Censuses of 1890, 1900 and 1910, and as estimated by the Passaic Valley Sewerage Commission for the year 1940, and accepted by the Central Committee of Experts for the State of New York, is as follows:

1892 Subdivision.	U. S. Census, 1890.	U. S. Census, 1900.	U. S. Census, 1910.	P. V. S. Com., 1940.
Passaic Co., Paterson City	78,347	105,171	125,600	276,000
" " Passaic "	13,028	27,777	54,773	128,400
" " Aquackononk	2,562	5,351	11,869	70,980
" " {Manchester, Prospect Park & Hawthorne.}	2,576	6,085	8,679	32,000
" " Totals (6)	96,513	144,384	200,921	507,000
Decennial increase, per cent.	49.6%	39.1%	.....	36.3%
Bergen Co., Saddle River	1,169	1,954	3,047	32,900
" " Garfield	1,028	3,504	10,213	30,000
" " Rutherford (48%)	1,101	2,117	3,382	20,040
" " Union (50%)	780	795	2,698	20,000
" " (9 smaller communities) (62%)	2,323	8,212	14,700	77,460
" " Totals (13)	6,401	16,582	32,380	180,400
Decennial increase, per cent.	159.05%	101.5%	.....	75.5%
Essex Co., Newark City (99%)	180,012	243,000	343,984	512,500
" " Orange "	18,844	24,141	29,630	60,000
" " E. Orange	13,282	21,508	34,371	70,990
" " Bloomfield	7,708	9,698	15,070	45,000
" " Belleville	3,487	5,907	9,891	51,000
" " Montclair	8,056	13,942	21,550	50,000
" " {Nutley & Glen Ridge}	.....	1,540	9,259	62,160
" " Totals (8)	231,969	320,736	463,775	851,580
Decennial increase, per cent.	38.4%	44.6%	.....	22.6%
Hudson Co., Harrison	8,238	10,596	14,498	29,200
" " East Newark	.....	2,500	3,163	5,600
" " Kearney	7,081	10,806	18,659	64,980
" " Totals (3)	15,319	23,902	36,320	109,780
Decennial increase, per cent.	55.9%	51.3%	.....	44.6%
Grand Totals (4 Counties)	350,202	505,711	734,396	1,649,420
Decennial increase, per cent.	44.3%	45.3%	.....	31.0%

Note.—The average decennial increase for Newark from 1910 to 1940 is only 14.3 per cent., whereas for the two decades preceding 1910 it was 35.2 and 41.2 per cent. The estimate of population in 1940 should therefore be increased somewhat.

The population of that portion of the Metropolitan Sewerage District in the State of New Jersey, which is not embraced in the Passaic Valley Sewerage District, will be found by subtracting the above totals for the Passaic Valley District from those given in the foregoing for all that part of the Metropolitan District lying in the State of New Jersey, as follows:

1893 Territory in New Jersey.	U. S. Census, 1890.	U. S. Census, 1900.	U. S. Census, 1910.	Estimated, 1940.
Totals for portion in New Jersey	720,948	1,028,240	1,487,287	3,437,660
Totals for Passaic Valley Dist.	350,302	505,711	734,396	1,649,420
Totals for Portion in New Jersey outside of Passaic Valley District ..	370,646	522,529	752,891	1,788,240
Decennial increase, per cent.	41.1%	44.1%	.....	33.5%

An examination of the foregoing figures for population and rates of decennial increase shows that the estimates for the year 1940 are in general very conservative; also that if the figures for Newark were properly increased the population of the entire Metropolitan Sewerage District in the year 1940 would become at least 13,000,000.

Communities Comprising the Passaic Valley Sewerage District.

Taken from Report of the Passaic Valley Sewerage Commission, 1908.

In Passaic Co.	Paterson, Manchester, Prospect Park, Hawthorne, Aquackononk and Passaic. Total	6.
In Bergen Co.	Glen Rock, Saddle River, Midland (20.5%), Garfield, Lodi Borough, Hasbrouck Heights (60.6%) Woodridge (34.7%) Wallington, Carlstadt (48.4%) East Rutherford (47.4%) Rutherford Union (48%) and North Arlington (50%) ..... Total	13.
In Essex Co.	Newark (99%) Nutley, Belleville, North Orange, Bloomfield, Glen Ridge Montclair and Orange ..... Total	8.
In Hudson Co.	Harrison, East Newark and Kearney ... Total	3.
	Total number of Communities.....	30.

1894 Communities in the State of New Jersey which now discharge sewage directly into Upper New York Bay, the Kill van Kull, and the lower portion of the Hudson River below Spuyten Duyvil, excluding the communities which now discharge sewage into Newark Bay, the Passaic and Hackensack Rivers, and the Arthur Kill.

Parts of Bayonne and Jersey City; also Hoboken, West Hoboken, Union, West New York, Weehawken, Guttenberg, Woodcliff, Edgewater, Fort Lee, and Englewood Cliffs. Total 12.

Communities in the State of New Jersey which now discharge sewage directly into Newark Bay and the Arthur Kill, excluding the Passaic and Hackensack Rivers:

Parts of Newark, Jersey City and Bayonne; also Elizabeth, Roselle Park, Irvington, South Orange, West Orange, Millburn, Summit, South Orange Township and Union Township, by means of a joint outlet sewer discharging at Elizabethport; also Rahway, Fanwood, Cranford and Garwood, through the Rahway River; also Roosevelt, Woodridge and Perth Amboy. Total 19.

NOTE.—In addition to the above, a number of other communities in New Jersey also discharge sewage into various small tributaries of the Arthur Kill.

Communities in the State of New York which now discharge sewage directly into Upper New York Bay, the East River, the Harlem River and the lower portion of the Hudson River below the north line of Yonkers:

Yonkers, upper part of Bronx Valley including White Plains, Scarsdale, part of Yonkers, Tuckahoe, Bronxville and part of Mt. Vernon.

Bronx Borough, Manhattan Borough and parts of the Borough of Brooklyn, Queens and Richmond. Total 11.

NOTE.—The East River ends and Long Island Sound begins at Throgs Neck. The communities which are embraced in theMetropolitan Sewerage District beyond the boundaries of the City of New York, and which now discharge sewage into Long Island Sound are: New Rochelle and Pelham in Westchester County, and
1895 Great Neck Landing and part of Great Neck in Nassau County.

Communities in the State of New York, which now discharge sewage directly into Newark Bay and the Arthur Kill: Parts of the Borough of Richmond (Staten Island).

Communities in the State of New York which now discharge sewage directly into Lower New York Bay, (below the Narrows) are: Parts of the Boroughs of Brooklyn, Queens and Richmond.

Q. Will you state the communities in the State of New Jersey now discharging sewage directly into the Upper New York Bay, the Kill van Kull and the Lower Hudson River?

A. Communities in the State of New Jersey now discharging sewage directly into Upper New York Bay, the Kill van Kull and lower Hudson River.

NOTE.—The entire community is here taken, instead of the part which is tributary to the waters mentioned. Time not available for making subdivisions.

Community.	1910.	Total.	1940.	Total.
Bayonne	55,545			
Jersey City	267,779			
Hoboken	70,324			
West Hoboken	35,403			
Union	21,023			
West New York	13,560			
Weehawken	11,228			
Guttenberg	5,647			
Woodcliff	470			
Edgewater	2,655			
Fort Lee	4,472			
Englewood Cliffs	410	488,516	.....	1,036,000

Communities in the State of New Jersey Now Discharging Sewage Directly Into Newark Bay and the Arthur Kill, Excluding the Passaic and Hackensack Rivers.

Community.	1910.	Total.	1940.	Total.
Part of Newark	†			
Part of Bayonne	†			
Part of Jersey City	†			
Elizabeth	73,409			
Roselle Park	3,138			
Irvington	11,877			
South Orange	6,014			
1896				
West Orange	10,980			
Millburn	3,720			
Summit	7,500			
South Orange Twnp.	2,979			
Union Twnp.	3,419	122,036		
Rahway	9,337			
Fanwwod	471			
Cranford	3,641			
Garwood	1,118			
Roosevelt	5,786			
Woodbridge	8,948			
Perth Amboy	32,121	61,422		
	183,458	183,548	472,240	472,240

NOTE.—† Denotes included in preceding table.

Communities in the State of New York Now Discharging Sewage Directly Into Upper New York Bay, the East River, the Harlem River, and the Lower Portion of the Hudson River.

Community.	1910.	Total.	1940.	Total.
Yonkers	79,803			
White Plains	15,045			
Scarsdale	1,300			
Tuckahoe	2,722			
Bronxville	1,863			
Mt. Vernon	30,919	131,652	.....	315,000
Bronx Borough	430,980	.....	1,200,000	
Manhattan Boro.	2,331,542	.....	3,600,000	
Part of Brooklyn Boro.	1,378,932	.....	2,500,000	
" " Queens "	204,153	.....	620,000	
" " Richmond "	63,702	4,409,309	96,000	8,016,000
	4,540,961	4,540,961	8,331,900	8,331,900

NOTE.—The above list does not include the communities in Westchester and Nassau Counties which discharge sewage into Long Island Sound within the limits of the Metropolitan District. These communities and their populations in 1910 are as follows:—New Rochelle 28,867; Pelham 2,908; Great Neck Landing and part of Great Neck, 1,783. Total (1910)—33,648.

Communities in the State of New York Now Discharging Sewage Directly Into Newark Bay and the Arthur Kill.

Community.	1910.	Total.	1940.	Total.
Part of Richmond	12,171	12,171	18,000	18,000

Communities in the State of New York Now Discharging Sewage Directly Into Lower New York Bay (Below the Narrows).

1897 Community.	1910.	Total.	1940.	Total.
Part of Brooklyn	255,419	.....	700,000	
" " Queens	79,888	.....	250,000	
" " Richmond	10,096	345,403	16,000	966,000

Summary of Communities in the States of New Jersey and New York now Discharging Sewage into New York Harbor Within the Metropolitan Sewerage District.

Communities.	1910.	1940.
A. 1. Passaic Valley District	734,396	1,649,420
A. 2. Hackensack "	72,838	200,000
B. N. J., Hudson River & Upper Bay	488,516	1,036,000
C. N. J. Newark Bay & Arthur Kill	183,458	472,240
D. N. Y., Hudson River & Upper Bay	4,540,961	8,331,900
E. N. Y. Newark Bay & Arthur Kill	12,171	18,000
F. N. Y. Lower New York Bay	345,403	966,000
	6,377,743	12,733,560
Communities in N. J. not enumerated in (A. 1.) and (C)	8,079	20,000
Communities in Westchester and Nassau Counties tributary to L. I. Sound, viz: New Rochelle, Pelham and Great Neck Note (D)	33,648	81,000
Communities in Westchester Co. tributary to Bronx River not enumerated in (D) viz: Parts of Greenburg, North Castle, and East Chester	5,060	12,000
Total in Metropolitan District	6,424,530	12,846,560

Average decennial increase: 26%.

Drainage Areas of Rivers Tributary to Newark Bay and New York Bay.

1898.	Sq. miles.
a. Passaic River above Newark Bay (N. J. Geol. Survey)	949.10
b. Hackensack River " " " " " "	201.60
c. Newark Bay, including water surface 8.6 Sq. M (E. K.)	32.48
d. Kill van Kull " " " 1.0 " " "	10.67
Total to mouth of Kill van Kull	1,193.85
e. Upper New York Bay, including water surface (21.0 sq. M.) (E. K.)	37.72
f. Lower East River, Battery to Stony Point, incl. water surface (E. K.)	40.41
g. Upper East River Stony Point to Throgg's Neck, including Bronx River, Westchester Creek & water surface (E. K.)	113.70
h. Harlem River, from Hudson River to East River (E. K.)	10.68
Sum	202.51
Sum of foregoing items	1,396.36
i. Hudson River, above its mouth (U. S. Geol. Survey)	13,366.00
Total drainage area above the Narrows	14,762.36
j. Arthur Kill, from Newark Bay to Raritan Bay, including Elizabeth and Rahway Rivers and Morse and Woodbridge Creeks, and water surface. (E. K.)	162.29
k. Lower New York Bay, land in Staten Island (E. K.)	20.07
l. " " " " " " Brooklyn "	12.12
m. Raritan River, above its mouth (N. J. Geol. Survey)	1,105.30
Total drainage area for Lower New York Bay	16,062.14

NOTE.—An area of 27.23 square miles included in the Metropolitan Sewerage District in Westchester County, is tributary to Long Island Sound (East of Throg's Neck). This area embraces Hutchinson's Creek water shed, New Rochelle and Pelham to Larchmont. The remaining large area tributary to the Sound is not here considered.

Flow of Rivers Tributary to Newark Bay and New York Bay.

Long continued observations of the flow of the various rivers tributary to Newark Bay and New York Bay are available only
1899 for the Upper Hudson River at Mechanicville, the Mohawk River at Dunsbach Ferry and the Passaic River at Dundee Dam. It is impracticable to make such observations in tidal waters, and hence they have been made at points more or less distant from the sea.

Observations of the flow of a few other rivers in the entire drainage area tributary to New York Bay have also been made through a period of a few years, and on comparing them with those of the first named rivers for the same period, little differences in the flow per square mile of watershed will be found. For present purposes it may

therefore be assumed that the flow of the rivers in Northern New Jersey is at the same rate as that of the Passaic River, and that the flow of those in southeastern New York is at the same rate as that of the Mohawk and Upper Hudson Rivers.

The drainage areas and available long periods of discharge observations on the said three principal rivers are as follows:

Hudson River at Mechanicville, N. Y., 4506 sq. miles	1891-1908	incl.
Mohawk " " Dunsbach Ferry, N. Y., 3440 sq. miles	1901-1909	"
Passaic " " Dundee Dam, N. J. 822 sq. miles	1877-1893	"

The aggregate area covered thereby is 8768 square miles, which is 59.4 per cent. of the total area of 14762 square miles above the Narrows in New York Bay.

Mr. McCarter: I suppose I ought at this point to interpose an objection to the use by this witness in a legal controversy of what he would be perfectly justified in using in a scientific paper, the data compiled by others in regard to these streams.

The Commissioner: Note the objection.

Q. Proceed Mr. Kuichling?

A. I can only say that those have been taken from official reports of state officers.

The average monthly and yearly flows of these rivers, expressed in depth in inches on their watersheds, are as follows:

1900 Month.	Hudson River. 18 years.	Mohawk River, 9 years.	Average of Hudson & Mohawk.	Passaic River. 17 years.
January	1.78"	1.76"	1.77"	3.12"
February	1.49	1.40	1.45	3.83
March	3.29	4.56	3.92	4.08
April	5.05	4.61	4.83	3.06
May	2.77	2.18	2.48	1.92
June	1.62	1.59	1.60	1.18
July	1.15	1.03	1.09	0.87
August	1.11	0.71	0.91	1.02
September	0.99	0.88	0.94	1.13
October	1.15	1.69	1.42	1.08
November	1.52	1.41	1.51	1.75
December	1.74	1.98	1.86	2.46
Yearly total	23.76"	23.81"	23.78"	25.50"

Minimum Dry Season Flow of Said Rivers.

On referring to the runoffs of said rivers for the four months: June, July, August and September,—the following minima will be found:

A. For single months.	June.	July.	August.	September.
Minimum for Hudson River.	0.65"	0.55"	0.36"	0.25"
In Year	1899	1908	1899	1908
Minimum for Mohawk River.	0.73"	0.51"	0.35"	0.17"
In year	1908	1909	1907	1908
Minimum for Passaic River.	0.32"	0.31"	0.26"	0.26"
In year	1880	1891	1882	1881

B. For 2 consec. months.	June & July.	July & August.	August & September.	September & October.
Minimum for Hudson River.	1.27"	0.98"	0.87"	0.89"
In year	1899	1899	1899	1891
Minimum for Mohawk River.	1.31"	1.07"	0.65"	0.80"
In year	1908	1901	1908	1908
Minimum for Passaic River..	0.74"	0.92"	0.53"	0.51"
In year	1880	1880	1881	1881

C. For 3 consec. months.	May, June & July.	June, July & August.	July, August & September.	Aug., Sept. & October.
Minimum for Hudson River..	2.81"	1.63"	1.25"	1.05"
In year	1891	1899	1908	1908
Minimum for Mohawk River.	3.89"	1.79"	1.23"	1.28"
In year	1902	1908	1908	1908
Minimum for Passaic River..	1.43"	1.24"	0.92"	0.78"
In year	1888	1880	1881	1881

*Weighted average see p. 1813.

1901 Least dry season flow of said rivers to be expected every 8 or 10 years. Found by taking the average of the two lowest Runoffs at intervals of from 5 to 10 years:

A. For single months.	June.	July.	August.	September.
For Hudson River	0.74"	0.59"	0.41"	0.38" } *
" Mohawk "	0.94"	0.56"	0.44"	0.36" } 0.366"
" Passaic "	0.38"	0.36"	0.55"	0.31" } say 0.37"

B. For 2 consec. months.	June & July.	July & August.	August & Sept.	September & October.
For Hudson River	1.33"	1.13"	1.03" } *	0.95" } *
" Mohawk "	1.31"	0.98"	0.86" } 0.935"	1.02" } 0.955"
" Passaic "	0.74"	0.90"	0.73" } say 0.94"	0.71" } say 0.96"

C. For 3 consec. months.	May, June & July.	June, July & August.	July, Aug. & Sept.	Aug., Sept. & October.
For Hudson River	2.95"	1.78"	1.37" } *	1.30" } *
" Mohawk "	3.89"	1.79"	1.23" } 1.292"	1.28" } 1.262"
" Passaic "	1.60"	1.41"	1.12" } say 1.29"	0.98" } say 1.26"

*Weighted average in proportion:

(Hudson River M.	=	4508	= 0.514
(Mohawk "	=	3440	= 0.392
(Passaic "	=	822	= 0.094
		87.08	1.000

A comparison of the foregoing runoff data for the Hudson, Mohawk and Passaic Rivers shows in general that the figures for the first two streams are not widely different, and hence that the runoff from their combined watershed will be given closely by taking the average of said figures. It is also seen that there is not much difference between the runoffs from the Hudson and Passaic watersheds, the former generally being a little greater than the latter during the period from May to October. As the monthly and annual rainfalls on the said three watersheds are likewise nearly equal, and as the watershed of the Hudson River above its mouth (13,366 sq. miles) is 90.5% of the total drainage area (14,762 square miles) above the Narrows, or foot of Upper New York Bay, it becomes justifiable to consider that the monthly runoff from the whole territory will be the same as that from the combined Hudson and Mohawk watersheds.

It should also be noted that according to the observations and studies of the U. S. Coast & Geodetic Survey, about 84% of the
1902 discharge from Newark Bay passes through the Kill Van Kull into Upper New York Bay, while the remaining 16% passes through the Arthur Kill (or Staten Island Sound) into Lower New York Bay. As the drainage area tributary to Newark Bay and Kill van Kull is 1194 square miles, it follows that only 84% of this area, or 1003 square miles, should be taken into account in estimating the quantity of upland water that flows into Upper New York Bay. Furthermore, it has also been customary to consider that little water from the Upper East River flows into Upper New York Bay, so that the drainage area of 114 square miles relating to the Upper East River should be omitted in estimating the flow of upland water into New York Bay. On this basis of computation, the virtual watershed above the Narrows will become (13,366+1,003+89)=14,458 square miles.

To estimate the mean monthly flow of upland water into Upper New York Bay, in terms of cubic feet per second, the given monthly runoff, expressed by the depth in inches on the watershed, must be multiplied by a certain factor corresponding to the area (14,458 sq. miles) and the number of days in the particular month. For a month of 31 days, such factor will here be 12,541; for a month of 30 days 12,959, and for a month of 28 days 13,884. Similarly for other periods of time and areas.

Mean monthly flow of upland water into Upper New York Bay, in cubic feet per second, based on the average monthly runoffs from the combined watershed of the Hudson and Mohawk Rivers.

Month.	Jan.	Feb.	March.	April.	May.	June.	July.
Av. Runoff.	1.77"	1.45"	3.92"	4.83"	2.48"	1.60"	1.09"
Discharge, c. ft. s. ...	22,198.	20,132.	49,161.	62,502.	31,102.	20,734.	13,670.

Month.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Av. Runoff.....	0.91"	0.94"	1.42"	1.51"	1.86"	23.78"
Discharge, c. ft. s.....	11,312.	12,181.	17,806.	19,568.	23,326.	25,328.

Minimum dry season flow of upland water into Upper New York Bay, in cubic feet per second, based on the averages of the minima for the Hudson and Mohawk Rivers.

1903

A. for single months.	June.	July.	August.	September.
Runoff (av. min.)	0.69"	0.53"	0.36"	0.21"
Discharge, c. ft. s.	8,942.	6,846.	4,515.	2,721.
B. for 2 consec. months.	**June & July.**	**July & August.**	**August & September.**	**September & October.**
Runoff (av. min.)	1.29"	1.02"	0.76"	0.85"
Discharge, c. ft. s.	8,221.	6,395.	4,843.	5,417.
C. for 3 consec. months.	**May, June, & July.**	**June, July, & August.**	**July, Aug., & Sept.**	**Aug., Sept., & Oct.**
Runoff (av. min.)	3.35"	1.71"	1.24"	1.10"
Dicharge, c. ft. s.	14,157.	7,226.	5,240.	4,902.

Least Dry Season Flow of Upland Water into Upper New York Bay, in cubic feet per second, to be expected every 8 or 10 years. Based on the averages for the Hudson and Mohawk Rivers for same conditions.

A. for single months.	June.	July.	August.	September.
Runoff (mean)	0.85"	0.58"	0.42"	0.37"
Discharge, c. ft. s.	10,886.	6,772.	5,267.	4,795.
B. for 2 consec. months.	**June & July.**	**July & August.**	**August & September.**	**September & October.**
Runoff (mean)	1.32"	1.00"	0.95"	0.98"
Discharge, c. ft. s.	8,412.	6,646.	6,054.	6,246.
C. for 3 consec. months.	**May, June, & July.**	**June, July, & August.**	**July, Aug., & Sept.**	**Aug., Sept., & Oct.**
Runoff (mean)	3.42"	1.78"	1.30"	1.29"
Discharge, c. ft. s.	14,453.	7,522.	5,494.	5,452.

The foregoing data relating to the flow of upland water into Upper New York Bay should be used with caution in considering the matter of the dilution of sewage in the waters of New York Harbor. A large volume of sea-water enters the harbor and flows out therefrom with every tide. The resultant tidal flow out from the harbor through all of its outlets must necessarily be equal to the aggregate flow of upland water into the harbor. The outlets of the harbor are at: 1. The Narrows; 2. Arthur Kill; and 3. Throgg's Neck at head of Long Island Sound. The tidal movements of the harbor waters are very complicated, and are described elsewhere in a report by Mr. H. de B. Parsons, and now in evidence in this case and marked Complainants' Exhibit No. 91.

1904 Rainfall Data.—Owing to the discontinuance of many stations where the precipitation from the atmosphere was regularly observed, also to broken records and the long distances between stations, it is often very difficult to estimate closely the average rainfall on extensive watersheds like that of the Hudson

River. The following figures for the yearly precipitation are derived from the best data now available:

Watershed.		No. of years.	Max.	Min.	Mean.
Mohawk River	1875–1900	25	51.53"	33.53"	40.71"
Upper Hudson River	1898–1901	14	49.92"	35.96"	41.68"
Croton River	1868–1905	38	63.75"	36.92"	48.96"
City of New York	1871–1910	40	58.66"	35.73"	44.62"
Passaic River	1877–1893	17	70.88"	35.70"	46.71"
Pequannock River	1895–1905	11	64.79"	36.67"	52.01"

NOTE.—It is of interest to note how nearly alike the minimum rainfall is on these different watersheds; and it is also very probable that if more numerous stations had been established in the mountainous portions of the watersheds of the Mohawk and Hudson Rivers, the mean annual precipitation thereon would have been somewhat higher.

Mr. McCarter: At this point objection is made to the use of this data as incompetent, irrelevant and immaterial.

The Commissioner: Note the objection.

Q. Now take up the precipitation?

A. The precipitation is shown in the following table——

Q. (Interrupting:) Before going on with the table, what do you mean by precipitation?

A. Precipitation is all the moisture that is precipitated in the form of water or snow or ice or hail from the atmosphere upon the surface of the land.

Q. That includes rain?

A. Yes, that is the water that would be rain, snow, ice and hail.

1905 Mr. McCarter: Same objection to the use of this data.

The Commissioner: Note the objection.

A. This is taken from the United States Weather Bureau.

New York City.

Precipitation in Inches.

Mean Monthly Figures.

	Figures for the last 40 years (1871 to 1910, inclusive). Maximum.	Minimum.	Normal.	Year. 1909.	1910.	1911.
January	6.15	1.15	3.79	3.33	5.61	2.27
February	7.81	0.82	3.74	4.31	4.07	3.17
March	7.99	0.86	4.10	3.19	0.86	2.87
April	7.02	1.60	3.30	5.93	4.53	3.06
May	9.10	0.33	3.18	1.72	1.66	0.91
June	7.70	0.86	3.20	3.17	5.10	4.63
July	9.63	0.23	4.54	1.08	0.23	1.55
August	10.42	1.18	4.52	7.94	2.13	7.38
September	14.51	0.15	3.59	2.06	1.43	1.51
October	11.55	0.58	3.71	0.74	3.79	5.38
November	9.82	0.75	3.44	1.58	4.62	4.22
December	6.66	0.95	3.45	5.09	1.95	....
Annual	58.68‡	35.72¢	44.63	41.35	35.99	....

‡ Precipitation for 1889, Maximum Year.
¢ Precipitation for 1895, Minimum Year.

From U. S. Weather Bureau.
Compiled by H. de B. Parsons.

1906 Q. And the mean monthly temperature for New York City?

Mr. McCarter: The same objection.
The Commissioner: Note the objection.

A. The table is as follows, compiled from the Weather Bureau:

New York City.

Mean Monthly Temperature in Degrees Fahrenheit.

	Figures for the last 40 years (1871 to 1910, inclusive). Maximum.	Minimum.	Normal.	1909.	Year. 1910.	1911.
January	40	28	30.2	32.2	32.4	34.8
February	40	23	30.7	37.3	31.4	31.4
March	48	29	37.5	38.3	44.7	37.6
April	54	41	48.1	49.5	54.0	48.2
May	66	54	59.3	60.4	60.3	63.6
June	72	64	68.5	70.5	68.0	68.3
July	78	70	73.5	73.4	77.8	76.0
August	77	69	72.2	71.6	72.2	71.8
September	72	61	66.5	65.6	68.4	66.6
October	61	50	55.6	53.2	56.1	55.6
November	50	37	44.0	47.7	41.6	41.4
December	42	25	34.4	31.4	28.0	....
Annual Mean	54.3‡	46.6¢	51.7	52.7	53.1	....

‡ Annual mean 1909, Maximum Year.
¢ Annual Mean 1875, Minimum Year.

From U. S. Weather Bureau.
Compiled by H. de B. Parsons.

1907 Q. Then give table for the relative humidity of New York City?

A. That is shown in the following table:

New York City.

Relative Humidity in Per Cent.

Mean Monthly Figures.

	Normal (20 years).	1909.	Year. 1910.	1911.
January	74	75	77	70
February	72	74	65	70
March	71	65	68	66
April	68	72	68	65
May	71	71	65	67
June	73	70	69	73
July	73	66	63	68
August	73	68	72	75
September	70	73	73	73
October	74	67	67	73
November	74	73	69	66
December	73	70	68	..
Annual Mean	73	70	69	..

From U. S. Weather Bureau.
Compiled by H. de B. Parsons.

Mr. McCarter: The same objection.
The Commissioner: Note the objection.

Q. Now, state the contents of table showing average velocity and prevailing directions of wind for N. Y. City?

A.—

Average Velocity and Prevailing Direction of Wind at New York City.

From U. S. Weather Bureau. Compiled by H. de B. Parsons.

		N.		N. E		E.		S. E.		S.		S. W.		W.		N. W.	
		Number of days.	Velocity.	Number of days.	Velocity.	Number of days.	Velocity.	Number of days.	Velocity.	Number of days.	Velocity.	Number of days.	Velocity.	Number of days.	Velocity.	Number of days.	Velocity.
June	1907.	1	8.2	3	15.0	1	10.9	4	7.3	12	7.4	1	9.2	4	14.8	4	8.8
	1908.	0	...	4	10.6	0	...	0	...	11	6.0	4	8.9	2	12.2	9	9.0
	1909.	0	...	7	10.6	1	8.0	2	8.9	2	6.8	7	8.3	5	10.8	6	11.0
	1910.	0	...	6	11.8	1	8.5	3	9.9	3	9.3	3	7.1	7	11.6	7	9.6
	1911.	4	10.7	2	13.0	6	13.6	5	11.7	1	9.1	2	10.4	4	13.2	3	10.4
Average....		1	10.5	4.6	13.4	1.8	9.6	2.8	9.4	5.5	8.2	3.4	8.8	4.4	12.5	6.2	12.1
July	1907.	1	7.0	1	6.2	0	...	2	7.0	11	6.9	6	9.2	6	12.4	4	14.4
	1908.	0	...	2	8.2	3	9.3	1	5.6	11	7.1	5	8.3	3	10.0	8	12.7
	1909.	1	7.4	1	8.4	0	...	4	7.8	10	7.0	3	10.2	3	14.2	9	14.9
	1910.	0	...	3	8.0	0	...	2	7.1	5	5.1	7	9.0	6	8.0	6	10.7
	1911.	0	...	3	11.3	1	10.0	4	11.0	1	12.0	13	14.3	5	14.3	5	16.3
Average....		0.4	7.0	2.0	8.4	0.8	9.9	2.6	7.8	7.0	8.4	6.6	10.0	4.6	11.8	6.0	13.8
August	1907.	1	7.0	4	9.2	1	7.1	1	8.1	12	7.9	2	9.4	3	10.5	7	11.1
	1908.	0	...	9	12.0	0	...	1	7.0	12	8.2	2	8.7	1	6.4	7	10.1
	1909.	0	...	5	12.0	2	13.5	3	9.7	5	7.4	5	8.6	2	9.8	8	11.2
	1910.	0	...	9	8.1	1	9.5	4	8.4	9	7.6	2	10.6	2	13.2	3	9.7
	1911.	1	11.0	1	10.0	3	11.7	3	11.6	3	9.5	11	12.0	3	13.7	4	20.0
Average....		0.4	9.4	5.2	11.6	1.8	10.4	2.4	9.0	8.2	8.1	4.4	10.1	2.4	10.5	6.2	12.3
September	1907.	0	...	5	12.4	2	9.2	1	11.0	6	9.4	7	9.2	6	14.1	3	7.0
	1908.	1	8.5	7	9.1	1	4.0	2	12.1	4	6.4	7	7.6	3	12.1	5	10.5
	1909.	1	7.7	4	9.9	3	8.9	4	8.8	3	6.8	3	7.1	1	14.1	11	12.3
	1910.	0	...	7	9.1	1	9.6	3	9.0	5	6.6	3	7.0	3	9.1	8	9.5
	1911.	8	16.0	3	13.0	3	12.1	2	12.1	2	13.7	0	14.9	3	13.7	3	18.9
Average....		2	10.9	5.2	10.7	2	8.2	2.4	10.8	4	9.0	5.2	9.1	3.2	12.0	6	11.7
4 Summer Months—																	
Total days		3.2		17.0		6.4		10.2		28.6		19.6		14.6		24.2	
Avg. velocity ..			10.3		10.8		9.8		9.2		8.4		9.8		11.7		12.8

*Velocities in miles per hour. Average of hourly readings.

1909 Mr. O'Sullivan: These are offered at this time to place on this record every fact and circumstance and all the data that operated upon this witness' mind in arriving at opinions which he will be requested for later.

Q. What is next Mr. Kuichling?

A. We now come to a series of tables showing the observed run-off on flow of the Hudson River at Mechanicsville, New York, for each month for the years 1888 to 1911 inclusive taken from the reports of the New York State Engineer and Surveyor.

Mr. McCarter: The same objection.

The Commissioner: Note the objection.

A. The tables are as follows:

1910 *Monthly and Yearly Depths of Runoff from the Watershed of the Hudson*

1910 ***Monthly and Yearly Depths of Runoff from the Watershed of the Hudson River at Mechanicsville, N. Y., in Inches on the drainage Area 4,506 Square Miles, from 1888 to 1911, Inclusive.***

From Reports of N. Y. State Engineer and Surveyor for 1901, 1910, and 1911.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1888	1.62	0.89	1.75	5.26	5.49	1.22	0.39	0.44	0.71	1.18	2.64	2.57	24.16
1889	2.81	0.88	2.12	3.39	2.27	1.70	1.47	1.09	0.49	0.96	1.96	3.39	22.53
1890	2.89	1.81	2.85	3.74	4.59	1.83	0.49	0.52	2.20	2.37	2.26	0.83	26.38
1891	2.12	2.70	4.54	4.96	1.42	0.79	0.60	0.68	0.50	0.38	1.01	2.20	21.90
1892	4.83	2.22	2.78	5.34	5.04	3.12	2.38	1.41	1.10	0.72	1.89	1.04	31.87
1893	0.82	1.06	2.27	4.44	5.71	1.19	0.64	1.28	1.71	0.99	0.90	1.84	22.85
1894	1.73	1.11	3.78	2.76	1.94	1.76	0.81	0.63	0.47	0.93	1.58	1.12	18.62
1895	0.99	0.82	1.07	5.90	1.75	0.70	0.66	1.00	0.64	0.67	2.09	2.79	19.08
1896	1.74	1.12	3.49	6.20	1.18	1.18	0.72	0.63	0.71	1.05	2.82	1.78	22.02
1897	1.02	0.91	3.13	4.73	3.12	2.93	2.85	2.11	0.68	0.64	2.47	3.69	28.28
1898	1.98	1.56	5.18	3.24	2.70	1.26	0.71	1.29	0.94	1.93	2.22	1.36	24.37
1899	1.65	1.19	2.39	6.11	2.46	0.63	0.62	0.36	0.51	0.67	1.51	1.88	19.98
1900	1.35	3.05	2.49	5.97	2.72	0.96	0.37	0.55	0.34	0.41	1.22	1.35	20.78
1901	0.70	0.41	2.20	7.13	3.45	2.35	0.72	1.12	0.93	1.05	0.87	2.19	23.12
1902	1.26	0.88	7.07	3.98	2.59	1.60	2.36	1.67	0.92	1.67	1.80	2.29	28.09
1903	1.83	2.22	7.63	3.73	1.11	2.39	1.42	1.59	1.14	2.31	1.19	1.20	27.76
1904	0.96	1.15	2.65	5.23	3.61	1.77	0.87	1.01	1.17	2.90	1.29	0.96	23.57
1905	1.48	0.59	1.80	4.73	1.78	2.03	1.07	1.56	3.00	1.68	1.53	2.10	23.95
1906	2.09	1.52	2.27	4.52	3.30	2.02	1.29	0.77	0.56	0.79	1.23	1.15	21.51
1907	1.85	0.77	2.24	3.87	3.38	1.26	0.97	0.45	1.18	2.37	3.46	2.97	24.77
1908	2.04	2.00	3.42	5.71	4.39	1.05	0.58	0.48	0.26	0.36	0.49	0.51	21.29
1909	1.45	3.13	2.57	6.84	4.76	1.55	0.57	0.40	0.37	0.43	0.46	0.59	23.12
1910	1.48	1.22	5.69	4.50	2.67	2.83	0.52	0.57	0.63	0.73	0.99	0.67	22.50
1911	1.49	0.89	1.54	4.37	2.51	1.17	0.42	0.38	0.62	1.99	2.20	2.72	20.30
Means	1.76	1.42	3.20	4.86	3.08	1.64	1.00	0.92	0.91	1.21	1.67	1.80	23.47
Max.	4.83	3.13	7.63	7.13	5.71	3.12	2.85	2.11	3.00	2.90	3.46	3.69	31.87†
Min.	0.70	0.41	1.07	2.76	1.11	0.63	0.37	0.36	0.26	0.36	0.46	0.51	18.62†

NOTE.—†These are not the sums of the monthly maxima and minima.

1911 *Monthly and Yearly Depths of Runoff from the Watershed of the Mohawk River at Dunsbach Ferry, N. Y., in Inches on the Drainage Area 3,440 Square Miles, from 1899 to 1911, Inclusive.*

From Reports of N. Y. State Engineer and Surveyor for 1902, 1904-1911.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
†1899	1.96	1.21	3.06	5.62	1.38	0.66	0.17	0.10	0.32	0.54	0.92	2.38	18.32
†1900	2.67	2.77	1.44	4.94	0.96	0.49	0.49	0.58	0.32	0.26	2.79	2.06	19.77
1901	0.86	0.34	3.13	5.89	2.22	2.05	0.54	0.53	0.55	0.69	0.65	2.79	20.24
1902	1.09	0.59	5.68	2.39	1.31	1.15	1.43	0.86	0.77	2.17	1.59	3.03	22.06
1903	=2.04	=3.01	9.19	3.27	0.58	3.36	2.14	=2.25	=0.96	4.05	1.38	1.41	33.64
1904	0.71	0.70	4.60	5.97	2.70	1.44	0.83	1.26	0.92	2.23	0.91	1.16	23.43
1905	1.78	0.41	3.86	5.06	1.56	1.97	1.41	1.23	2.79	1.60	1.76	3.00	26.43
1906	1.39	1.51	3.08	5.03	2.36	1.43	1.07	0.55	0.37	0.82	1.72	1.43	20.76
1907	4.13	0.70	3.68	3.36	2.21	1.01	0.79	0.35	1.02	2.39	2.93	3.28	25.85
1908	1.62	2.71	4.62	4.79	3.51	0.75	0.58	0.48	0.17	0.63	0.98	0.97	21.79
1909	2.54	4.17	3.23	5.73	3.19	1.22	0.51	0.38	0.42	0.59	0.78	0.76	23.52
1910	2.18	1.21	5.63	3.05	1.92	2.26	0.45	0.60	0.65	0.77	1.41	0.69	20.82
1911	1.76	1.28	2.80	4.88	1.61	1.44	0.28	0.17	0.75	1.37	2.05	–1.91	20.30
Means	1.90	1.59	4.15	4.61	1.96	1.48	0.82	0.72	0.77	1.40	1.53	1.91	22.84
Max.	4.13	4.17	9.19	5.97	3.51	3.36	1.43	–2.25	2.79	4.05	2.93	3.28	!33.64
Min.	0.71	0.34	1.44	2.39	0.58	0.49	0.17	0.10	0.17	0.26	0.65	0.69	!18.32

NOTES—†Denotes record at Rexford Flats, N. Y., a few miles above Dunsbach Ferry.
=Denotes record at Little Falls, N. Y.; no record for Dunsbach Ferry.
–Denotes mean for month used; no record for Dunsbach Ferry.
!These are not the sums of the monthly maxima and minima.

Monthly and Yearly Depths of Runoff from the Watershed of the Passaic River at Dundee Dam, N. J., in Inches on the Drainage Area 822 Square Miles, from 1877 to 1893, Inclusive.

From Report of Geological Survey of New Jersey, 1894, Vol. 3.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1877	0.92	2.30	6.02	3.06	0.98	0.63	0.44	0.60	0.36	2.98	5.34	2.53	26.16
1878	2.67	3.75	3.84	1.43	1.77	1.67	0.80	1.62	0.52	0.49	1.75	6.83	27.14
1879	0.82	1.83	4.12	4.37	1.71	0.97	0.45	1.60	0.93	0.24	0.26	2.42	19.72
1880	3.55	2.64	2.55	2.09	1.04	0.32	0.42	0.50	0.48	0.22	0.74	0.68	15.23
1881	1.14	3.59	6.77	1.68	0.89	1.89	0.39	0.27	0.26	0.25	0.57	1.65	19.35
1882	2.20	6.90	4.35	1.23	3.04	1.90	0.94	0.26	3.86	1.68	0.57	1.14	28.07
1883	0.91	3.03	3.16	2.94	1.67	0.71	1.04	0.38	0.35	1.09	1.30	0.75	17.33
1884	2.83	6.21	5.01	2.68	1.85	0.64	1.33	0.88	0.32	0.59	0.99	3.36	26.69
1885	4.15	2.24	1.96	3.50	1.68	0.52	0.42	0.78	0.26	0.76	2.73	3.25	22.25
1886	3.54	5.68	2.64	5.10	3.38	1.04	0.52	0.49	0.31	0.33	0.92	1.15	25.10
1887	2.84	4.84	3.63	2.66	1.10	2.04	2.29	1.35	0.38	0.66	0.59	2.32	24.70
1888	4.61	3.90	4.97	6.13	0.69	0.38	0.36	1.00	4.19	2.65	3.00	4.51	36.39
1889	5.75	2.28	2.19	3.41	2.85	1.65	2.31	4.14	3.90	2.15	6.29	4.40	41.32
1890	2.01	3.24	3.30	2.99	2.74	1.78	1.47	1.04	1.52	2.49	1.37	1.98	25.93
1891	5.92	5.41	5.30	4.49	0.94	0.44	0.31	0.83	0.64	0.31	0.63	2.04	25.26
1892	5.34	1.55	2.66	1.43	1.42	1.20	0.52	0.53	0.40	0.25	1.38	1.18	17.86
1893	3.86	5.65	6.95	4.88	4.88	2.32	0.71	1.05	0.58	1.25	1.30	1.74	35.17
Means	3.12	3.83	4.08	3.06	1.92	1.18	0.87	1.02	1.13	1.08	1.75	2.47	25.51
Max.	5.92	6.90	6.95	6.13	4.88	2.32	2.31	4.14	4.19	2.98	6.29	6.83	†41.32
Min.	0.82	1.55	1.96	1.23	0.69	0.32	0.31	0.26	0.26	0.22	0.26	0.68	†15.23

NOTE.—† These are not the sums of the monthly maxima and minima.

1913 *Monthly and Yearly Depths of Runoff from the Watershed of the Passaic River at Chatham, N. J., in Inches on the Drainage Area* 101 *Square Miles, from* 1903 *to* 1909, *Inclusive.*

From Reports of U. S. Geological Survey, W. S. & I., Papers Nos. 166, 202, 241, and 261.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1903	....	....	7.69	4.21	0.09	3.69	1.80	3.29	3.64	6.57	0.79	4.24	....
1904	....	....	....	2.79	1.06	0.52	0.43	2.92	2.88	1.92	1.26	....	.....
1905	....	....	....	1.86	0.40	0.38	0.24	1.11	3.05	0.50	0.30	2.68	.....
1906	2.32	1.26	3.34	4.72	1.13	0.89	1.52	1.60	0.05	0.40	0.74	0.97	18.94
1907	6.58	0.52	7.99	1.98	3.14	0.71	0.34	0.20	1.50	2.40	5.06	3.78	34.20
1908	3.46	3.17	4.10	0.99	4.20	1.03	0.59	0.60	0.38	0.06	0.37	1.52	21.07
1909	2.08	4.52	2.71	3.30	1.71	0.29	0.20	0.42	0.18	0.12	0.16	1.48	17.17

Monthly and Yearly Depths of Runoff from the Watershed of the Delaware River at Port Jervis, N. Y., Drainage Area 3,250 *Square Miles, and at Riegelsville, N. J., in Inches on the Drainage Area* 6,430 *Square Miles, from* 1905 *to* 1909, *Inclusive.*

From Reports of U. S. Geological Survey, W. S. & I., Papers Nos. 241 and 261.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
†1905	2.97	0.38	5.25	3.19	1.01	0.79	0.51	0.62	2.00	1.27	1.01	2.88	21.88
1906	†2.11	†1.47	†3.11	†5.74	†1.76	†2.34	1.12	0.94	0.55	1.04	1.52	1.37	23.07
1907	3.20	0.91	3.82	2.00	1.65	1.20	0.70	0.37	0.90	1.94	3.84	4.58	25.11
1908	2.65	3.17	5.42	3.19	4.04	1.10	0.63	0.38	0.27	0.59	0.71	0.00	22.75
1909	2.42	4.79	3.03	3.41	3.06	1.29	0.55	0.40	0.32	0.32	0.29	0.68	21.16

NOTE.—† Refers to data at Port Jervis, N. Y.

1914 Q. What is your next data?

A. The next I have on physical data would be a summary of the float experiments that have been made by the Metropolitan Sewerage Commission. They are already in evidence. I should say that this summary does not embrace all of the float experiments that have been put in evidence, for the reason that quite a number of these observations did not cover the entire range of the tide, but only a fractional portion of it. Neither do they include those in the Upper East River and Long Island Sound, because that is a water that is not tributary to the Lower New York Bay or Upper New York Bay to an appreciable extent.

They have been arranged by localities, and according to ebb tide and flood tide, the intention being to show the distance traveled by the tidal currents for ebb and flood respectively.

These tables are as follows:

Summary of Float Experiments.

Ex. No.	Float No.	Date.	Locality.	Tide current.	Duration of run H. Mi.	Length of run Mi.	Mean vel. Mi. Hr.	Run comp. with total tidal mov't.
4	1(a)	Feb. 23/07	Upper Bay	Ebb	7-30	12.00	1.61	Complete.
"	1(b)	" 25 "	" "	"	5-45	10.00	1.74	Nearly complete.
"	1(c)	" 26 "	" "	"	6-00	9.11	1.52	" "
6	3(b)	Mar. 25 "	" "	"	5-05	7.98	1.59	" "
"	3(c)	" 27 "	" "	"	5-30	9.51	1.73	" "
7	4(c)	Apr. 3 "	" "	"	7-25	10.48	1.41	" "
8	5(c)	" 12 "	" "	"	4-55	11.29	2.29	Complete.
10	7(a)	July 9 "	" "	"	6-30	10.64	1.64	Nearly complete.
61	31	Sept. 22/08	" "	"	4.34	5.21	1.12	" "
62	32	" 25 "	" "	"	4.20	6.40	1.48	" "
74	47	Nov. 11/09	" "	"	5.27	11.13	2.04	Complete.
"	"	Nov. 11, 12/09	" "	"	5-10	7.50	1.45	Nearly complete.
76	49	" 16/09	" "	"	4-21	6.45	1.43	Incomplete.
"	"	" 17 "	" "	"	5-02	5.20	1.03	Complete.
78	55	" 29 "	" "	"	8.45	16.26	1.86	"
79	56	Dec. 3 "	" "	"	7-50	10.75	1.37	"
80	57	" 7 "	" "	"	7-40	7.25	0.95	"
"	"	" 7-8 "	" "	"	7-30	7.00	0.93	"
80	58	" 9-10 "	" "	"	5-55	9.60	1.62	"
Totals 19.....		Feb.-Dec.	" "	"	115-14	173.85	.....	"
Means "		"	" "	"	6-04	9.15	1.509	"

1916 Ex. No.	Float No.	Date.	Locality.	Tide current.	Duration of run H. Mi.	Length of run Mi.	Mean vel. Mi. Hr.	Run comp. with total tidal mov't.
5	2(b)	Mar. 5/07	Upper Bay	Flood	6-45	7.26	1.08	Complete.
"	2(d)	" 22 "	" "	"	5-00	2.82	0.56	Nearly complete.
6	3(a)	" 23 "	" "	"	4-00	2.58	0.65	" "
7	4(d)	Apr. 4 "	" "	"	4-35	4.27	0.93	" "
11	8(a)	July 17 "	" "	"	5-55	6.77	1.14	" "
59	29	Sept. 17/08	" "	"	4.50	4.10	0.85	Complete.
64	34	" 28 "	" "	"	6-18	9.14	1.44	Nearly complete.
66	37	Oct. 1 "	" "	"	6-20	6.87	1.09	Complete.
74	47	Nov 11/09	" "	"	4-53	6.25	1.28	"
74	47	" 11 "	" "	"	6-50	5.75	0.84	"
76	49	" 16 "	" "	"	5-55	5.60	0.95	"
80	57	Dec. 7 "	" "	"	4-10	2.70	0.65	"
80	57	" 7 "	" "	"	6-25	6.50	1.00	"
81	58	" 9 "	" "	"	4-55	4.90	1.00	"
Totals 14.....		Mar.-Dec.	" "	"	76-51	75.51	.....	"
Means 14.....		"	" "	"	5-29	5.39	0.982	"
5	2(a)	Mar. 4/07	Lower Bay	Ebb	4-15	10.72	2.52	Nearly complete.
6	3(d)	" 28 "	" "	"	4-30	13.14	2.92	" "
74	47	Nov. 11-12 "	" "	"	5.10	7.50	1.45	" "
78	55	" 29-30 "	" "	"	5-05	7.25	1.43	Complete.
78	55	" 30/07	" "	"	7-00	11.75	1.68	"
79	56	Dec. 3 "	" "	"	10-25	9.35	0.90	"
79	56	" 4 "	" "	"	4-55	7.55	1.60	Nearly complete.
80	57	" 8 "	" "	"	9-20	10.50	1.12	" "
81	58	" 9-10 "	" "	"	5-55	9.60	1.62	Complete.
81	58	" 10 "	" "	"	5-00	4.15	0.83	Nearly complete.
Totals 10.....		Mar.-Dec.	" "	"	61-35	91.81	.....	" "
Means		"	" "	"	6-10	9.18	1.491	" "

1917

Ex. No.	Float No.	Date.	Locality.	Tide current.	Duration of run H. Mt.	Length of run Mi.	Mean vel. Mi. Hr.	Run comp. with total tidal mov't.
8	5(d)	Apr. 13/07	Lower Bay	Flood	3-00	6.69	2.23	Incomplete.
78	55	Nov. 29-30/09	" "	"	3-50	3.50	0.91	Complete.
78	55	" " "	" "	"	5-45	6.75	1.17	"
79	56	Dec. 3 "	" "	"	1-10	0.75	0.64	"
79	56	" 3-4 "	" "	"	4-30	4.45	0.99	"
80	57	" 8 "	" "	"	1-20	1.80	1.35	"
81	58	" 10 "	" "	"	4-30	6.05	1.34	"
Totals 7.....		Apr.-Dec.	" "	"	24-05	29.99	.....	"
Means ".....		"	" "	"	3-26	4.28	1.246	"
7	4(b)	Apr. 2/07	Hudson River	Ebb	5-00	12.01	2.40	Nearly complete.
11	8(b)	July 19/07	" "	"	6-15	11.93	1.91	" "
"	8(c)	" 22 "	" "	"	6-00	6.13	1.02	" "
43	24	Sept. 9/08	" "	"	5-44	11.00	1.92	Complete.
73	46	Nov. 8-9/09	" "	"	4-32	9.77	2.16	Nearly complete.
"	"	" " "	" "	"	5-00	6.39	1.28	" "
74	47	" 9 "	" "	"	3-30	12.13	1.87	Complete.
"	"	" 10-11 "	" "	"	6-15	10.30	1.65	"
Totals (8).....		Apr.-Nov.	" "	"	45-16	79.66	.....	"
Means "		"	" "	"	5-40	9.96	1.760	"

1918

Ex. No.	Float No.	Date.	Locality.	Tide current.	Duration of run H. Mi.	Length of run Mi.	Mean vel. Mi. Hr.	Run comp. with total tidal mov't.
5	2(b)	Mar. 5/07	Hudson River	Flood	6-45	7.26	1.08	Complete.
11	8(a)	July 17/07	" "	"	5-56	6.77	1.14	Nearly complete.
64	34	Sept. 28/08	" "	"	6-18	9.14	1.44	" "
66	37	Oct. 1/08	" "	"	6-20	6.87	1.09	Complete.
73	46	Nov. 8-9/09	" "	"	3-15	2.26	0.70	"
74	47	" 10/09	" "	"	5-30	5.31	0.97	"
Totals (6).....		Mar.-Nov.	" "	"	34-03	37.61	.....	"
Means "		"	" "	"	5-41	6.27	1.104	"
			Lower					
7	4(a)	Mar. 29/07	East River	Ebb	6-40	14.23	2.13	Complete.
45	10	Aug. 24/08	" "	"	4-30	9.70	2.16	Nearly complete.
46	16	" 31 "	" "	"	3-47	8.63	2.30	" "
47	23	Sept. 8 "	" "	"	5-04	13.00	2.55	" "
49	38	Oct. 3 "	" "	"	4-49	10.48	2.18	Complete.
75	48	Nov. 15/09	" "	"	4-50	6.82	1.41	"
78	55	" 29 "	" "	"	8-45	16.26	1.86	"
80	57	Dec. 6-7 "	" "	"	7-55	12.38	1.56	"
Totals (8).....		Mar.-Dec.	" "	"	46-20	91.50	.....	"
Means "		"	" "	"	5-48	11.44	1.975	"

1919

Ex. No.	Float No.	Date.	Locality.	Tide current.	Duration of run H. Mi.	Length of run Mi.	Mean vel. Mi. Hr.	Run comp. with total tidal mov't.
5	2(c)	Mar. 7/07	Lower East River	Flood	5-20	7.90	1.48	Complete.
40	38	Oct. 3/08	" "	"	5-47	9.14	1.58	"
50	39	Oct. 5	" "	"	6-20	8.97	1.42	"
68	36	Sept. 30	" "	"	4-52	9.60	2.00	"
70	49	Nov. 17/09	" "	"	7-28	10.72	1.48	"
Totals (5).....		Mar.-Nov.	" "	"	29-47	46.42	.....	"
Means "		"	" "	"	5-57	9.28	1.559	

Table of Distances in New York Harbor Compiled by E. Kuichling, C. E.

(By Air Lines Unless Otherwise Noted.)

Passaic Light		(Newark Bay)	is	1.55	miles	S.	from	Mouth of Passaic River.
" "		" "	is	3.70	"	N.	"	Bergen Point (hd. Kill van Kull).
" "		" "	is	4.40	"	N.	"	Elizabethp't (hd. Arthur Kill).
Bergen Point		" "	is	1.95	"	E.	"	" " " " "
" "		" "	is	3.00	"	W.	"	Constable Hook (ft. Kill van Kull).
Constable Hook		(Upper N. Y. Bay)	is	5.00	"	S. W.	"	Battery (Manhattan).
" "		" " "	is	4.50	"	S. W.	"	Castle Williams (Governors Is.).
" "		" " "	is	4.00	"	S. W.	"	Red Hook (South Brooklyn).
" "		" " "	is	0.85	"	N. W.	"	St. George (Ferry), Staten Is.
" "		" " "	is	1.25	"	W.	"	Robbins Reef Light.
" "		" " "	is	4.10	"	N. W.	"	Ft. Lafayette (Narrows).
" "		" " "	is	3.75	"	N. W.	"	Ft. Wadsworth (Narrows).
" "		" " "	is	4.90	"	E.	"	Elizabethport (hd.) Arthur Kill).
St. George (Staten Is. Ferry)		" " "	is	4.90	"	S. W.	"	Battery (Manhattan).
" "		" " "	is	4.35	"	S. W.	"	Castle Williams, Gov. Is.
" "		" " "	is	3.65	"	S. W.	"	Red Hook (So. Brooklyn).
" "		" " "	is	3.30	"	N. W.	"	Ft. Lafayette.
" "		" " "	is	5.85	"	N. W.	"	Norton's Pt. (Coney Is.).
" "		" " "	is	12.50	"	N. N. W.	"	Sandy Hook Light.
			is	5.55	"	E.	"	Elizabethport (hd. Arthur Kill).
Ft. Wadsworth		(Staten Is. Narrows)	is	9.50	"	N. N. W.	"	Sandy Hook Light.
" "		" " "	is	13.40	"	N. E. E.	"	Perth Amboy Point.

"	"	"	"	"	is	2.95	" N. W.	" Nortons Pt. (Coney Is.).
"	"	"	"	"	is	0.85	" W.	" Ft. Lafayette (Narrows).
"	"	"	"	"	is	6.88	" S. S. W.	" Battery (Manhattan).
"	"	"	"	"	is	6.30	" S. S. W.	" Castle Williams (Gov. Isl.)
"	"	"	"	"	is	5.31	" S. W.	" Red Hook (S. Brooklyn).
"	"	"	"	"	is	3.60	" S.	" Robbins Reef Light.

1921

Ft. Lafayette		(B'klyn side—Narrows)			is	9.50 miles	N. N. W.	from Sandy Hook Light.
"	"	"	"	"	is	14.25	" N. E. E.	" Perth Amboy Point (Mouth of Raritan River and Arthur K.).
"	"	"	"	"	is	6.50	" S. S. W.	" Battery (Manhattan).
"	"	"	"	"	is	5.92	" S. S. W.	" Castle Williams, Gov. Is.).
"	"	"	"	"	is	4.95	" S. S. W.	" Red Hook (S. Brooklyn).
"	"	"	"	"	is	3.69	" S. S. E.	" Robbins Reef Light.
"	"	"	"	"	is	4.10	" S. E.	" Constable Hook.
"	"	"	"	"	is	3.30	" S. E.	" St. George (Ferry) Staten Is.
"	"	"	"	"	is	0.85	" E.	" Ft. Wadsworth.
Nortons Point		(W. End of Coney Is.)			is	7.18 miles	N.	" Sandy Hook Light.
"	"	"	"	"	is	14.38	" N. E. E.	" Perth Amboy Pt. (Raritan R.).
"	"	"	"	"	is	2.95	" S. E.	" Ft. Wadsworth (Staten Is.).
"	"	"	"	"	is	2.52	" S. E. S.	" Ft. Lafayette (Narrows).
"	"	"	"	"	is	5.80	" S. E.	" St. George Ferry (Staten Is.).
"	"	"	"	"	is	6.18	" S. E. S.	" Robbins Reef Light.
"	"	"	"	"	is	6.62	" S. E.	" Constable Hook.
"	"	(via Ft. Lafayette)			is	9.02	" S.	" Battery (Manhattan).
Robbins Reef Light		(Upper Bay)			is	0.54	" N. W. W.	" N. J.-N. Y. State line (through Upper Bay).
"	"	"			is	0.34	" N.	" N. J.-N. Y. State line (through Kill van Kull).

"	"	"	is	1.25	"	E.	" Constable Hook.
"	"	"	is	0.92	"	N. R.	" St. George (Ferry) Staten Is.
"	"	"	is	2.35	"	S. E. E.	" Main Shore of Bayonne, N. J.
"	"	"	is	2.00	"	N. W. W.	" Brooklyn shore (Bay Ridge).
"	"	"	is	3.98	"	S. W.	" Battery, Manhattan.
"	"	"	is	3.43	"	S. W.	" Castle William, Gov. Isl.
"	"	"	is	2.80	"	S. W. W.	" Red Hook (So. Brooklyn).
"	"	"	is	3.69	"	N. N. W.	" Ft. Lafayette.
"	"	"	is	3.60	"	N.	" Ft. Wadsworth.
"	"	"	is	6.18	"	N. W. N.	" Nortons Pt. (Coney Is.).
Battery (Manhattan)		"	is	0.60	"	N.	" Castle Williams, Gov. Isl.

1922

Battery (Manhattan)		Upper Bay	is	1.55	miles	N.	from Red Hook (So. Brooklyn).
"	"	" "	is	1.72	"	N. E. E.	" Bedloes Island (Liberty).
"	"	" "	is	3.98	"	N. E.	" Robbins Reef Light.
"	"	" "	is	5.00	"	N. E.	" Constable Hook.
"	"	" "	is	4.90	"	N. E.	" St. George (Ferry), Staten Is.
"	"	" "	is	6.88	"	N. N. E.	" Ft. Wadsworth.
"	"	" "	is	6.50	"	N. N. E.	" Ft. Lafayette (Brooklyn).
"	"	" "	is	9.02	"	N.	" Nortons Pt. (via Ft. Lafayette).
"	"	" "	is	16.00	"	N.	" Sandy Hook " "
"	"	" "	is	13.05	"	S. S. W.	" Spuyten Duyvil (Harlem Riv.).
"	"	" "	is	4.47	"	S. W.	" S. End Blackwell's Island.
"	"	" "	is	6.27	"	S. W.	" N. " " "
"	"	" "	is	6.74	"	S. W.	" Hallets Point (Hell Gate).
"	"	" "	is	6.96	"	S. W.	" S. W. corner Wards Island.
"	"	" "	is	7.68	"	S. W.	" S. W. " Randalls Isl.
"	"	" "	is	8.36	"	S. W. S.	" 2nd Ave. Bridge, Harlem River.

"	"	"	"	is	8.54	" S. W.	" Stony Point (Port Morris).
Stony Point (Port Morris)		(Upper East River)		is	8.54	" N. E.	" Battery (Manhattan).
"	"	"	"	is	2.26	" N. E.	" N. End Blackwells Island.
"	"	"	"	is	1.79	" N. E.	" Hallet's Point Light.
"	"	"	"	is	1.60	" N. E.	" S. W. Corner Wards Island.
"	"	"	"	is	0.96	" N. E.	" S. W. " Randalls Island
"	"	"	"	is	1.18	" S. E. E.	" 2nd Ave. Bridge (Harlem Riv.).
"	"	"	"	is	0.67	" W.	" Mid. N. Brother Island.
"	"	"	"	is	1.21	" W.	" N. Point (light) Rikers Isl.
"	"	"	"	is	1.47	" W.	" Barrets Point (N. Shore).
"	"	"	"	is	3.06	" W.	" College Pt. (S. Shore).
	"	"	"		4.16	" W.	" Old Ferry Point (N. Shore).
"	"	"	"	is	6.32	" W.	" Throggs Neck Light.
"	"	"	"	is	6.70	" W.	" Willetts Point Light.

Harlem River from Hudson River to 2nd Ave. Bridge is 6.25 miles long.

1923 Q. Mr. Kuichling, have you given special study to the Passaic Valley sewerage project?

A. I have.

Q. What general data relating to the Passaic Valley sewerage project did you take under consideration?

A. —

General Data Relating to the Passaic Valley Sewerage Project.

According to the Report of the Passaic Valley Sewerage Commission published in 1908, the Sewerage project under consideration contemplates the construction of a trunk sewer from a point near the Great Falls of the Passaic River in the City of Paterson, along the westerly side of the river to a point on the Newark meadows near the L. V. R. R. Bridge where the sewage is to be partly clarified; the liquid will thence be pumped through a long tunnel under Newark Bay, Bayonne and a part of Upper New York Bay, and finally discharged through a system of large distributing pipes laid on the bottom of the Upper Bay near Robbins Reef Light, where the water is about 40 feet deep.

The total length of the trunk sewer, tunnel and main outlet pipe to the beginning of the system of distributing pipes on the bottom is 26.23 miles. The diameter of the sewer ranges from 4.0 ft. to 13.5 feet, that of the tunnel is 12.0 feet; and that of the two outlet pipes is 8.0 feet. The estimated aggregate drainage area of the sewer above the pumping station is 140.02 square miles, but it is stated that of this area only 103.23 square miles will be tributary to the trunk sewer. The population of this latter area was 519,043 in 1900, and was estimated by the Commission to become 702,400 in 1911, and to reach 1,649,440 in 1940.

The volume of sewage from the said tributary area was estimated to be 89,343,000 gallons per day in dry weather in 1905, and to reach a maximum of 357,365,200 gallons per day in 1940. This latter figure is made up of the following items:

	Gallons.
Domestic sewage from 1,649,440 people at 150 gals. per day	247,416,000
Ground water infiltration from East side of river	3,429,300
Ground water infiltration from West side of river	44,037,800
1924 Manufacturing wastes from the various industries	62,482,100
Total	357,365,200

It is also stated that this figure represents the estimated maximum rate of discharge during the hours of the day when the consumption of water by persons and trades is greatest. The average rate during the 24 hours of the day is regarded as being only about two-thirds of the maximum rate for sewage and trades waste, the ground water in filtration remaining the same.

Comments on the Foregoing Data.—A study of the problem has led to the conclusion that the volume of sewage proposed to be discharged by the Passaic Valley Sewerage Commission into Upper New York Bay in the year 1940 is not as large as will probably be the fact. The reasons for this conclusion are based on the following grounds, viz:

1. Restriction of the area to be served by the trunk sewer.
2. Under-estimate of the population on the area in 1940.
3. Under-estimates of volume of infiltering ground water.
4. Under-estimate of the volume of industrial wastes.
5. No provision in the trunk sewer for storm-water.

Drainage Area.—The drainage area tributary to the proposed trunk sewer is not necessarily limited to 103.23 square miles, but may readily be increased 40 per cent. or more in the future, thereby increasing both the tributary population and the volume of sewage.

Population.—The growth of population has been greater than as estimated by the Passaic Valley Sewerage Commission, as the estimate of this Commission was 702,400 in 1911, whereas it was 734,400 in 1910 according to the U. S. Census of that year. The decennial increase from 1900 to 1910 was 45.3 per cent. or 4.53 per cent. per year, and at this rate of increase the population in 1911 would be 767,700 in 1911, or 9.3 per cent. more than was estimated. Furthermore, with the estimated population of 1,649,440 in 1940 and the actual population of 734,400 in 1910, the average decennial rate of increase is only 31.0 per cent., which is much less than the rate of 44.3 per cent. for the decade from 1890 to 1900, and the rate of 45.3 per cent. for the decade from 1900 to 1910. No sound reason can be given for considering that the growth of population will decrease materially in the next three decades to 1940. There is abundant space available in the said 103.23 square miles for a much large- population, and the location of the district is very favorable for presuming that the rate of increase during the past 20 years will continue with little abatement during the next 30 years.

1925

In the case of the City of Newark, N. J., the under estimate of the Passaic Valley Sewerage Commission becomes very apparent. The decennial increase of that city from 1890 to 1900 was 35.2 per cent., and from 1900 to 1910 it was 44.2 per cent., the average of these two rates being 38.2 per cent. For the period from 1910 to 1940, however, the estimate indicates an average decennial growth of only 14.3 per cent., this being for populations of 344,000 in 1910 and 512,500 in 1940. If a decennial rate of 35.0 per cent were taken, the population of Newark would be about 846,400 in 1940, or 333,900 more than was estimated by said Commission.

The estimates for all the other cities and burroughs in the Passaic Valley Sewerage District exhibit a more reasonable rate of future growth. Excluding Newark, the aggregate population in 1910 was 390,452, and the estimate for 1940 is 1,137,440, thus giving an average decennial rate of growth of 42.8 per cent., while during the decade from 1900 to 1910 the actual growth was 49.0 per cent. In the same decade the growth of population in nine cities and towns in Westchester County,

N. Y., was from 151,423 in 1900 to 237,199 in 1910, or 56.6 per cent.; and similarly, in eight neighboring cities and towns in New Jersey, namely: Jersey City, Hoboken, Bayonne, Elizabeth, Union, Perth Amboy Hackensack and Rutherford, the population increased from an aggregate of 397,389 in 1900 to 541,296 in 1910, or at the rate of 36.2 per cent.

A study of the population statistics thus indicates that the probable number of people in the Passaic Valley Sewerage District in the year 1940 will be nearer 2,000,000 than 1,649,440 as estimated by the Commission in 1908, and hence also that the daily quantity of sewage to be discharged as proposed will be correspondingly increased. 1926

Maximum Rate of Discharge.—Exception is also taken to the estimated maximum rate of discharge of the proposed trunk sewer in the year 1940. As stated above, this rate is expressed in terms of gallons per day, the figure being 357,365,200 gallons per day, or 553 cubic feet per second. It is composed of four items, viz: domestic sewage at the rate of 150 gallons per capita, ground water infiltration at the rate of about 700,000 gallons per square mile per day from 64.85 square miles of territory on the west side of the Passaic River, and about 100,000 gallons per square mile per day from 31.75 square miles on the east side of the river, and manufacturing wastes at the average rate of $\frac{62,482,100}{1,649,440}$=37 88 gallons per capita per day.

Domestic Sewage.—Concerning the rate of 150 gallons per head per day for domestic sewage, no strong exception is taken. It is based on the assumption that the quantity is 100 gallons per head in 24 hours, and that one-half thereof is produced in 8 hours, thus making the production during these 8 hours at the rate of 150 gallons per day. The statistics of water supply of our large American cities in which waste is prevented as much as practicable, show that a minimum consumption of 100 gallons per head per day for domestic and general commercial purposes may be expected; but they also show that a liberal addition must be made for water used for industrial purposes, as will be mentioned subsequently.

It may also be remarked that the same statistics indicate that the per capita consumption tends to increase with the growth of the community at a rate ranging from 0.5 to 1.0 per cent. per year; hence in making estimates for new or additional water supplies, the future per capita consumption is usually taken at a larger rate than the present one.

Thus, in the report of the Boston Metropolitan Water Board, dated January 1, 1901, p. 38, it is stated that the consumption of water in that District had risen from 73.3 gallons daily per person in 1890 to 112.8 gallons daily per person in 1900, or increased 54 per cent. in ten years; and in 1908 it had increased to 129 gallons. In the estimates for the extension of the Boston Metropolitan Sewerage System made in 1898, a large increase was considered probable, and in the report of that Board, dated January 1, 1905, page 175, it is stated that the assumed per capita rates of 147 1927

gallons of sewage per day in 1905 and 175 gallons per day in 1940, are fully justified from the studies of sewage flows in the Metropolitan District sewers since 1898. (This statement was made in the report of Wm. M. Brown Engineer of the Sewerage Works, and refers to "separate" sewers receiving no storm water.) In the Report of the Commission on Additional Water Supply for the City of New York" made on November 30, 1903, by Engineer W. H. Burr, R. Hering and J. R. Freeman, when the average daily consumption was about 115 gallons per capita, it is stated on pp. 14 and 68 that in the estimate for the future requirements of the City a less quantity than 150 gallons per head per day 25 years hence (or in 1930) should not be taken. Numerous other instances of similar nature are also available.

In the cases just cited, the per capita daily supply includes the quantity of water required in large cities for manufacturing purposes, which may range from 20 to 40 gallons per head per day when great industries requiring relatively large volumes of water are left out of account. On the basis of 150 gallons per capita for the future requirement of the City of New York, there will accordingly be left for domestic and ordinary commercial purposes a quantity of from 110 to 130 gallons per head per day. It is thus seen that an estimate of 100 gallons per capita daily for future domestic and commercial uses may be regarded as a low minimum.

Ground Water Infiltration.—In regard to the estimates for the infiltration of ground water into the trunk sewer and systems of tributary sewers, the reason for assuming a flow from only 96.6 square miles out of a nominal total of 103.2 square miles, and a possible total of more than 140 square miles, is not very clear; neither is the great difference in the assumed maximum rates of infiltration from the territories on the west and east sides of the river made plain. It may be presumed that both of these areas will undergo the same development, and that under-drainage will be done on all lands where the ground water comes near the surface. It is also improbable, from the estimates of population and industrial wastes, that a large proportion of the total area will be rendered impervious to the rainfall and surface drainage waters, so that a substantial reduction of the quantity of ground water cannot be expected. Furthermore, it must be remembered that the large trunk sewer will be laid along the western side of the river, and its top will be below the level of the river's surface for the greater portion of its length.

1928

Adjourned to June 13th, 1912 at 10:30 A. M.

Supreme Court of the United States, October Term, 1911.

PEOPLE OF THE STATE OF NEW YORK, Complainants,
vs.
STATE OF NEW JERSEY and THE PASSAIC VALLEY SEWERAGE COMMISSION, Defendants.

CORPORATION COUNSEL'S OFFICE,
NEW YORK, June 13th, 1912—10:30 a. m.

Present: James D. Maher, Esq., Commissioner.

1929 Appearances:

Dr. Wm. J. O'Sullivan, Special Counsel for the People of the State of New York, Complainants,
Adrian Riker, Esq., for The Passaic Valley Sewerage Commission, Defendants.

Met pursuant to adjournment.

EMIL KUICHLING, a witness called on behalf of the Complainants, recalled for further examination, testified as follows:

Direct examination by Mr. O'Sullivan (resumed):

Q. Now, Mr. Kuichling, taking up where we left off yesterday. Now, referring to the matter of ground water infiltration into the sewer?
A. The matter of ground water infiltration into a sewer.

Cross-examination by Mr. Riker:

Q. What is this witness using to testify from?
A. A transcript of my manuscript notes, made some time ago.
Q. A copy of your notes made at the time of your observations?
A. At the time of my report on the subject to counsel for the Complainants.
Q. And this report, did it refer to anything except your own personal observations of facts?
A. Yes. It referred to other facts observed by others, and reported by them.

Mr. Riker: I object to the use of this report on the ground that it does not even purport to be a memoranda to refresh the witness' memory or to be used for that purpose.
The Commissioner: Note the objection.

Direct examination by Mr. O'Sullivan (resumed):

Q. Proceed, Mr. Kuichling.

Mr. Riker: I desire to put a further objection on the record, that

I object to the method of this witness giving testimony in narrative form, reading from a report, which precludes the possibility of objections to specific questions as put.

1930 The Commissioner: The objection will be noted.

Mr. Riker: I shall move to strike out the whole of his testimony on the ground that it is volunteered and not responsive to any question.

Mr. O'Sullivan: Counsel for Complainants desires to inform Counsel for Defendants that during his absence yesterday afternoon, and while Mr. Robert H. McCarter was in charge of the defendants' interests, during the hearing, that the unfinished answer, which the witness on the stand is now completing is clearly responsive to the question put by Complainants' Counsel, during the absence of Mr. Riker, who makes these objections.

The Commissioner: The objections are noted.

A. The estimate of 700,000 gallons per square mile per day for the territory on the west side of the river is based on a number of dry weather gaugings of the discharge of an outlet sewer in Union, in combination with estimates of the amount of sewage proper, the difference being considered ground-water infiltration. The area drained by this sewer is about 12 square miles and the computations given in the Report of the Passaic Valley Sewerage Commission indicate that the leakage or infiltration ranged from 5,010,000 gallons per day in 1896 to 9,000,000 gallons per day in 1903, with an average of 6,432,000 gallons per day during the 12 years 1895-1906 inclusive. From these figures it was concluded that the inflow of ground water into the systems of local sewers would be at an average rate of 350,000 gallons per square mile of tributary area per day, and that the maximum rate would be twice as much, or 700,000 gallons per square mile per day. On the east side of the river the maximum infiltration was assumed to be at the rate of 100,000 gallons per square mile per day, "which is double what is usually estimated."

While these figures seem to be large, they are in reality much less than has been directly measured in many other places. In land drainage experiments, fields having an area of several acres were under-drained by lines of tile laid a few rods apart and con-

1931 nected to a single outlet pipe where the volume of ground water thus intercepted was measured. Various English, French and German experiments of this kind show discharges ranging from about 1,000,000 to 6,700,000 gallons per square mile per day. Of eleven such estimates given by eminent authorities, the average of the six lowest is 1,644,000 gallons per square mile per day, and that of the five highest is 4,085,000 gallons per square mile per day. Another low estimate is 864,000 gallons per square mile per day.

A more common method of expressing the amount of ground water infiltration is at the observed rate of flow per mile of sewer built, instead of per square mile of surface drained; and still another method is to express it in terms of gallons per day per head of population served by the sewer system. Numerous instances of measure-

ment of infiltration are given in a paper by J. P. Folwell, C. E., published in "Engineering Record" of November 7, 1903, Vol. 48, p. 564. It is there stated that in many sewer systems the infiltration is from 50 to 100 per cent. of the volume of sewage proper per day; also that in Boston, Mass., H. A. Carson, C. E., estimated from extensive measurements of the flow in the main sewerage system in 1889, that the infiltration was at the rate of 45 gallons per head of population per day, while in Providence, Rhode Island, it was 47 gallons per head per day; also that in Norfolk, Virginia, in 1888, ground water formed at least 60 per cent. of the pumpage of sewage, or about 100 gallons per head per day, while in Malden, Mass., it was 65 gallons per head per day.

Mr. Folwell further stated that in thickly-populated areas of our smaller American cities, the number of inhabitants per mile of sewer is about 800. On this basis the rate per mile of sewer per day in the above-named cities would be 36,000 gallons in Boston; 37,600 in Providence; 80,000 in Norfolk, and 52,000 in Malden. He also gives other data of this kind as follows:—In about 4,000 feet of brick sewer in East Orange, New Jersey, the rate was 570,000 gallons per mile per day, but in 21 miles of 8 inch pipe sewers it was only about 9,000 gallons per mile per day; in Malden it was 50,000 gallons per mile per day on the average for 38 miles of sewer, and if only the length laid in wet ground were taken into account, the infiltration would be 83,000 gallons per mile per day; a concrete sewer lined with 21-inch earthenware pipe, laid in tunnel through wet sand and gravel, admitted ground water at the rate of 140,000 gallons per mile per day; in Westboro, Massachusetts, in 1899, the infiltration into 1950 feet of 15 inch vitrified pipe sewer was 489,000 gallons per day, or at the rate of 1,320,300 gallons per mile per day, and in another section of the same sewer 1,060 feet long, it was at the rate of 610,000 gallons per mile per day; in Peoria, Ill., about 3,000 feet of vitrified pipe for carrying the water supply, and laid with special care, showed an outward leakage of about 100,000 gallons per mile per day; in New York, N. Y., the inflow of ground water into a system of 5 miles of sewers ranging from 8 to 24 inches in diameter, was found to be about 1,300,000 gallons per mile per day; he also quotes from a report made in 1900 by X. H. Goodnough, C. E., to the Massachusetts State Board of Health, stating that about 137 miles of sewers ranging from 8 to 36 inches in diameter had recently been constructed in and near Boston, and that the infiltration was at the average rate of 40,000 gallons per mile per day before any buildings had been connected thereto.

1932

In view of these observations, along with a number of others not quite so definite, Mr. Folwell states that "it seems desirable to allow for a leakage of 50,000 to 100,000 gallons per mile per day wherever pipe sewers are laid below the ground water level, and about 15 gallons per square foot per day for the submerged brickwork of larger sewers, except where the sewer is built in a manner different from the common practice."

A similar paper by E. S. Rankin, C. E., Engineer of Sewers of

Newark, N. J., printed in "Engineering Record" of October 31, 1903, Vol. 48, p. 532, states that in a recent investigation of an outlet sewer for a portion of Newark and several adjacent towns, the infiltration into 3 miles of 42-inch sewer was found to be about
1933 270,000 gallons per mile per day, and in about 15 miles of tributary sewers ranging from 8 to 15 inches in diameter, it averaged 107,000 gallons per mile per day. This paper was discussed (l. c.) by E. Adam, C. E., City Engineer of Newark, N. J., who stated that many of the old brick sewers in that city were built without mortar joints in the bottom, the result being a sewage flow of 48,000,000 gallons per day while the total water supply of the city was only 25,000,000 gallons per day. It may be remarked that in 1903 the population of Newark was about 274,000, thus making the water supply about 91 gallons and the dry-weather sewage flow 175 gallons per head per day; also that the total length of all public and private sewers in the city, up to December 31, 1903, was 198.7 miles. (Annual Report of the Board of Street and Water Commissioners of Newark, N. J., for 1903, p. 118), whence the infiltration is $\frac{23000000}{198.7}$ =115,752 gallons per mile of sewer per day on the average.

Additional data relating to infiltration into Sanitary Sewers, mostly of small size, are given in a paper by E. D. Rich, C. E., in "Engineering Record", of October 1, 1910, Vol. 62, p. 377, as follows:—At Canton, Ohio, 20-inch pipe sewer, the rate was 70,000 gallons per mile per day; at New Bedford, Massachusetts, 12-inch pipe sewer, it was 17,000 gallons per mile per day; at Brockton, Mass., in 16 miles of pipe sewers of various size, it was 25,000 gallons per mile per day; at Altoona, Pa., it was 40,800 gallons per mile in a 27-inch pipe sewer, 86,600 gallons per mile in a 30-inch pipe sewer, and 264,000 gallons per mile in 33" x 44" brick sewer, per day in all cases. Another interesting example relates to the infiltration into a system of 13.38 miles of pipe sewers, ranging from 6 to 18 inches in diameter, laid in 1889 in an area of 746 acres or 1.16 square miles in Stamford, Conn. The infiltration was measured soon after the work was completed in 1889, and was found to be 885 gallons per acre per day, or 49,340 gallons per mile per day on the average; in 1892 it was again measured by Engineers G. E. Waring, Jr., and John Bogart, and was found to have increased to 1,689 gallons per acre, or 94,170 gallons per mile per day, as published in "Engineering Record" of 1892, II, p. 247.

1934 To indicate the importance of this subject to sewerage engineers, reference is also made to the report of Engineers H. P. Eddy and J. B. F. Breed, on the construction of a new system of sewers in Louisville, Kentucky, 1910, pp. 33 and 57. The City is located on *on* undulating plain, covered to a depth of about 10 feet with alluvial clay, below which is found coarse sand and in some places gravel. These permeable strata contain large quantities of ground water, from which many manufacturers pump their supply of water for condensing purposes, and it was estimated that about 12,000,000 gallons per day were thus derived. In designing

the principal intercepting sewer, which serves a territory of 7,829 acres or 12.23 square miles, it was deemed prudent to provide for an unavoidable infiltration of ground water at the average rate of 1,960 gallons per acre, or 1,254,400 gallons per square mile per day, and furthermore to assume that the maximum rate of such inflow would be double the average rate, or 2,508,800 gallons per square mile per day.

As some of the foregoing estimates refer to rate of infiltration of ground water per head of population per day, it is worth while to ascertain the average number of persons per mile of sewer in American cities, and for this purpose use has been made of the data given in the special report of the U. S. Census Bureau entitled "Statistics of Cities, 1905." The following 15 cities have been taken to obtain averages, viz:—Allegheny, Pa.; Boston, Mass.; Buffalo, New York; Cleveland, Ohio; Columbus, Ohio; Detroit, Michigan; Jersey City, N. J.; Kansas City, Mo.; Memphis, Tennessee; Milwaukee, Wis.; Newark, N. J.; Pittsburg, Pa., Providence, Rhode Island; Rochester, New York; and Syracuse, New York. The populations range from 117,129 to 595,380 with an aggregate of 4,011,314; the areas range from 7 to 40 square miles, with an aggregate of 350 square miles; the number of miles of sewers ranges from 111.5 to 700.6, with an aggregate of 4,715.9 miles; the number of miles of sewer per square mile of municipal area ranges from 10.5 to 18.4, with an average of 13.5; the number of inhabitants per mile of sewer ranges from 545 to 1,496, with an average of 851; and the number of inhabitants per square mile of municipal
1935 area ranges from 6,895 to 20,407, with an average of 11,461.

It will be observed that in the estimates of the Passaic Valley Sewerage Commission, a future population of 1,649,440 is given to an area of 103.23 square miles, thus providing for an average density of population of 16,000 per square mile in 1940, which is much more than the average of said 15 cities in 1905. By taking the 6 cities in the foregoing list which have the largest average densities of population, viz:—Allegheny, Boston, Jersey City, Milwaukee, Newark and Pittsburg, the following results will be obtained:—The populations range from 142,848 to 595,380 with an aggregate of 1,931,325; the areas range from 7 to 38 square miles, with an aggregate of 125 square miles; the number of miles of sewers ranges from 111.5 to 700.6, with an aggregate of 1,945.5 miles; the number of miles of sewer per square mile of municipal area ranges from 11.9 to 18.4, with an average of 15.6; the number of inhabitants per mile of sewer ranges from 824 to 1,496, with an average of 993; and the number of inhabitants per square mile of municipal area ranges from 12,557 to 20,407, with an average of 15,451.

This last-named figure agrees closely with the aforesaid average density of population in the Passaic Valley Sewerage District in 1940, viz: 16,000 per square mile, and hence it may be assumed that the other relations deduced from the said six cities will also apply to that District. On this basis, there will be in said District

in the year 1940 an aggregate of about 103.23 x 15.6 = 1,610.4 miles of sewers tributary to the proposed trunk sewer; and if the infiltration of ground water is at an average rate of 50,000 gallons per mile of sewer per day, the total will be 80,520,000 gallons per day. The maximum rate will, however, be at least 50 per cent. greater, so that the item of maximum ground water infiltration will be about 121,000,000 gallons per day, instead of 47,467,100 gallons per day as estimated by the said Commission. Taking the entire populated area of 103.23 square miles into account, the maximum infiltration just computed will be at the rate of only 1,172,000 gallons per square mile per day, which is very near the
1936 lower limit of observed ground-water discharge from underdrained fields, and very far from the upper limit of such discharges.

At 1 P. M. adjourned to Noon recess until 2 P. M.

CORPORATION COUNSEL'S OFFICE,
NEW YORK, June 13th, 1912—2 p. m.

EMIL KUICHLING a witness called on behalf of the Complainants and recalled for further examination, testified as follows:

Direct examination by Mr. O'Sullivan (resumed):

Q. Proceed, Mr. Kuichling, where you left off before recess.

A. It should be noted that the average rate of 50,000 gallons per mile per day for infiltration into sewers, as used in the foregoing computation, is very low in comparison with the data relating to Newark, N. J. (115,750), the joint outlet sewer (107,000) in the vicinity of that city, and Stamford, Conn. (94,170). These figures indicate that a rate of at least 100,000 gallons per mile per day should have been taken. The rate used is the same as was found in the Malden, Massachusetts, sewer system of 38 miles; and as the estimated future population of the territory under consideration is 1,026 per mile of sewer, the per capita rate is about 50 gallons per day, or half of the estimated water supply. In view of the much larger rates found elsewhere, and the location of the large trunk sewer close to the west bank of the river, and below the natural level of the ground water for the greater part of its length, it follows that the said rate of 50,000 gallons per mile per day should be regarded as an underestimate of what is likely to occur.

The significance of this matter of infiltration is that a large proportion of the capacity of the proposed trunk sewer is necessarily taken up by the ground water, so that the capacity of the
1937 sewer for receiving domestic sewage and industrial wastes is correspondingly reduced. Obviously all such liquids which cannot be accommodated in the trunk sewer, must escape into the river at the various relief overflows of the tributary sewers, and hence the desired purification or betterment of the condition of the Passaic River will not be attained.

Q. In your studies of the Passaic Valley sewerage project did

you give any study to the question of storm water,—what its effect is, the volume and other matters in relation to their influence on the project?

Mr. Riker: I object to the question as calling for matter that is immaterial to the issues in this cause.

The Commissioner: Note the objection.

A. I did give such consideration.

Another feature of the project is that no provision is made for the interception of an appreciable quantity of storm water. In combined systems of sewerage, the first runnings of the sewers during a rainfall are always exceedingly foul, and should be admitted into the interceptor or trunk sewer in order to undergo the prescribed treatment at the sewage disposal works. Usually a volume of storm water equal to about twice the dry-weather flow is thus admitted, as it has been found that the subsequent storm runnings of the sewers are far less offensive in character and can safely be discharged into the river. In separate systems of sewerage, more or less storm-water will also find its way into the sewers at many places, thereby increasing the volume of sewage considerably. In the separate system of sanitary sewers of the City of Reading, Pa., which had been developed in 1910 to accommodate 6,082 house connections, the maximum daily flow in the several months of that year was from 24 to 90 per cent. more than the minimum daily flow, and from 10 to 30 per cent. more than the average daily flow. Similar variations have also been observed in other places having separate systems of sewers, and it is therefore evident that adequate provision for this unavoidable increment of volume should be made. On this point, see p. 75 of Kershaw's "Modern Methods of Sewage Purification," London, 1911.

1938 Q. Confining yourself to the data given in the report of the Passaic Valley Sewerage Commission?

A. An examination of the data given in the said Report of the Passaic Valley Sewerage Commission shows that the last five sections of the proposed trunk sewer, above the pumping station, range from 11.5 to 13.5 ft. in diameter and have an aggregate length of 31,670 feet or almost 6.0 miles; also that the estimated volume of liquid when delivered at the assumed maximum rate ranges from 184.33 million gallons per day, or 285.2 cubic feet per second, to 357.37 million gallons per day, or 553.0 cubic feet per second; that the grade of these five sections is 0.38 feet per thousand feet, and that these discharges are expected to fill the sections to a depth of three-fourths their diameters. From the figures relating to the last section, it is found that with the use of the coefficient of surface roughness (n)=0.015 in the Kutter formula, the coefficient of discharge (c) in the formula $v=c\sqrt{rs}$ for the mean velocity of flow in the sewer will be: c=122.0 for flowing at the depth of three-fourths the diameter; and that by taking the same value of (c) when the sewer is flowing completely filled, the discharge will be 625.0 cubic feet per second. The reserve discharging capacity be-

tween flow at ¾ depth and full depth of diameter is thus only (625—553)=72 cubic feet per second.

The stated maximum rate of discharge of 553 cubic feet per second in 1,940 consists, according to said estimates, of 383 cubic feet of domestic sewage, 96.5 cubic feet of trade wastes and 73.5 cubic feet of infiltered ground-water; hence the reserve capacity, available for storm water, viz: 72 cubic feet per second, amounts on this basis to only 18.8 per cent. of the volume of domestic sewage. It cannot be claimed seriously that this small percentage of reserve capacity will be sufficient to receive the first foul runnings of the tributary sewers when flushed in the early stage of a moderate rainfall; nor that the interception of only the dryweather flow of the various sewerage systems of the extensive district, as indicated
1939 by the afore-said data, will result in the desired improvement of the Passaic River. Furthermore, it must be remembered that no reserve capacity whatever will be available in 1940, in view of the strong probability that the infiltration of ground water into the sewerage systems and large trunk sewer will greatly exceed the estimated allowance therefor, as pointed out in the foregoing.

In this connection, it may be noted that in most projects for preventing the pollution of inland rivers by intercepting and treating the sewage of bordering communities, provision has been made for taking also a considerable volume of storm water. Thus in designing the sewerage works of London, England, 50 years ago, it was deemed expedient to intercept storm-water at the rate of 6.73 cubic feet per square mile of area per second; but in recent projects much more is taken. After studying the subject of sewage disposal for 12 years, the British Royal Commission reported in 1908 their conclusions in regard to storm water as follows:—"Storm overflows on branch sewers should be used sparingly, and should usually be set so as not to come into operation until the flow in the branch sewer is several times the maximum normal dry-weather flow therein. No general rule can be laid down as to the increase in flow which should occur in the branch sewers before sewage is allowed to pass away by the overflow untreated. * * * The general principle should be to prevent such an amount of unpurified sewage from passing over the overflow as would cause nuisance." From this statement it is very clear that a provision for intercepting storm-water to the extent of less than one-fifth of the volume of domestic sewage alone cannot be regarded as adequate. It may also be added that if the small proportion of storm water adopted in London long ago were to be applied to the area of 103.2 square miles under consideration, the resulting volume would be 694 cubic feet per second in the last section of the proposed trunk sewer, or 1.8 times the assumed volume of 383 cubic feet per second of domestic sewage in 1940.

In general the same principles apply to both large and small projects, and it is unsound to consider that because the Passaic Valley Sewerage project relates to a large territory and in-
1940 volves great expense, the fundamental principles for securing reasonably clean water in the Passaic River should be modi-

fied in important degree in order to curtail the cost. It is safe to say that in designing sewage works for the individual cities and communities in this district; provision would be made for treatng the first runnings of the sewers follwoing a storm; and there is no other reason why the same provision——

Mr. Riker: I desire to interpose a Notice of Motion to strike out the matter that concerns the purification of the Passaic River, as not being germane to this inquiry.

The Commissioner: Note the objection.

Mr. O'Sullivan: The reasons given for the advancement of this project are that it is necessary to purify the Passaic River, and we show that it fails even in that particular.

Mr. Riker: I shall move to strike it out as impertinent and irrelevant.

The Commissioner: Note the motion.

Q. Proceed, Mr. Kuichling.

A. And there is no other reason why the same provision should not be made for the aggregation of communities, excepting the one of expense. To indicate how much larger the last section of the proposed trunk sewer above the pumping station would have to be made in order to accommodate in 1940 a volume of storm water equal to the estimated volume of domestic sewage alone, it may be stated that the diameter would have to be increased 2.25 feet provided that the other quantities remained as estimated.

Q. Mr. Kuichling, in your consideration of the Passaic Valley Sewerage project did you devote any study to the industrial wastes that were contemplated to be carried in that trunk sewer?

A. I did. In the report of the Passaic Valley Sewerage Commission, made in 1908, the industrial wastes in the year 1940 from a population of 1,649,440 are estimated as 62,482,100 gallons per day at their maximum rate of discharge. The average rate of discharge during the 24 hours of the day is not given, and in order to 1941 form an opinion as to the sufficiency of this estimate, it becomes necessary to make the usual assumption that three-fourths of the total daily volume of such wastes are discharged uniformly in a period of 10 hours. On this basis the maximum hourly rate of discharge will be nine-fifths of the average hourly rate, thus making the average rate five-ninths of the maximum rate; so that the aforesaid estimate becomes equivalent to a volume of only 34,712,300 gallons per day, or 21 gallons per head of total population per day.

In considering this estimate of industrial wastes it must be remembered that the Passaic Valley from Paterson to Newark is already famous for the variety and magnitude of its manufacturing enterprises, and it is highly improbable that they will diminish in the future; on the contrary, there is ample reason to believe that many new industries will be established in this territory in proportion as the population increases. Paterson has great silk mills and manufactures more than three-fourths of all the silk textiles used

in America; Passaic has the largest woolen mills now in the World; Newark has a multitude of industries; and in the intermediate towns many extensive chemical works are in full operation. According to data obtained in 1909 by the U. S. Census Bureau, the principal textile mills and breweries alone of Newark, Passaic and Paterson discharge about 31,000,000 gallons of trade wastes per day from an aggregate population of 506,700 in that year, thus giving an average per capita discharge of more than 61 gallons per day. Presumably the many other factories in the territory use large quantities of water, so that it is very likely that the aforesaid estimate of 34,712,300 gallons per day of industrial wastes in the year 1940 is already exceeded in the present year 1912.

A study of the volume of manufacturing wastes produced in a large number of American and foreign cities shows that the same ranges from 10 to 200 gallons per head of total population per day. The data refer mostly to years since 1900, and were published by responsible authorities. Some of the figures are given in the following table:—

1942 *Table of Volume of Industrial Wastes Produced Daily in Various Cities, Together with Population at Time of Observation.*

City.	Population.	Volume of Industrial Wastes.	
		Per head per day.	In City per day.
		Gallons.	*Gallons.*
I. American:			
Boston, Mass., 1892.....	430,200	30	12,906,000
Brockton, Mass., 1909.....	56,000	41	2,250,000
Cleveland, O., 1909.....	540,000	39	21,125,000
Columbus, O., 1905.....	150,000	26	3,900,000
Erie, Pa., 1910.....	66,500	59	3,924,000
Gloversville, N. Y., 1909....	20,600	48	989,000
Harrisburg, Pa., 1910.....	70,000	73	5,110,000
Kansas City, Kan., 1910....	82,000	85	6,970,000
Milwaukee, Wis., 1911.....	373,900	57	21,312,000
New York, N. Y., 1900.....	2,050,600	24	49,214,000
Newark, N. J., 1909.....	333,600	15	5,000,000
Passaic, N. J., 1909.....	52,600	80	4,200,000
Paterson, N. J., 1909.....	120,500	183	22,000,000
Providence, R. I., 1909.....	215,500	33	7,000,000
Rochester, N. Y., 1903.....	174,000	18	3,132,000
Sacramento, Cal., 1909.....	43,000	70	3,000,000
Syracuse, N. Y., 1905.....	114,000	40	4,560,000
Wilmington, Del., 1910.....	87,500	46	4,025,000
Total for 18 cities....	4,979,500	36	180,617,000
Excluding New York:			
Total for 17 cities....	2,928,900	45	131,403,000

II. English:			
Bradford, 1908	270,000	29	7,830,000
Burton on Trent, 1908	45,000	139	6,255,000
Keighley, 1905	42,000	19	798,000
Leeds, 1908	450,000	15	6,750,000
Lichfield, 1905	8,000	25	200,000
Luton, 1908	38,500	18	693,000
Nottingham, 1908	260,000	15	3,900,000
Reigate, 1905	28,000	16	448,000
Trowbridge, 1905	11,600	29	336,000
Wakefield, 1905	43,000	28	1,204,000
Total for 10 cities	1,196,100	24	28,414,000
III. German:			
Aachen, 1905	155,000	23	3,565,000
Bochum, 1910	145,000	42	6,090,000
Essen, N. W., 1910	70,000	124	8,680,000
Munchen-Gladbach, 1905	66,000	62	4,092,000
Recklinghausen, 1910	30,000	21	630,000
Total for 5 cities	466,000	49	23,057,000

1943 It should be noted that the figures given in the preceding table must be regarded as under-estimates, because in many cases they do not include all the manufacturing wastes of the cities, but refer only to those derived from the principal industries. In other cases they represent only the volume of water taken for manufacturing purposes from the public water works, and do not include the additional supplies of water taken by factories from rivers and wells. It is also very difficult to determine the true volume of such wastes owing to seasonal irregularities of production, local requirements for treatment before discharge into sewers, temporary shortage of supply, accidents to machinery, etc. The figures, moreover, refer to the average daily volume, and not to the maximum rate of production during a part of the day.

In view of the foregoing considerations, I am of the opinion that an allowance of at least 50 gallons per head of total population per day should be made for the industrial wastes that will be produced in the Passaic Valley Sewerage District in 1940, and that should be excluded from the Passaic River. This volume will therefore have to be discharged into the proposed trunk sewer, and will amount in 1940 to 1,649,440 x 50=82,472,000 gallons per day, if the estimate of population made by the Passaic Valley Sewerage Commission be adopted. There is, however, good reason to believe that the population of said District will become at least 1,800,000 in the year 1940, in which event the volume of industrial wastes will become about 90,000,000 gallons per day on the average, and the maximum rate of discharge will be nine-fifths of the average or about 160,000,000 gallons per day.

Q. In pursuing your line of studies on the Passaic Valley project, did you make any estimate of the prospective volume of liquid to be discharged by the trunk sewer in 1940?

A. I did.

It is my opinion that a conservative estimate of the volume of liquid to be discharged by the proposed trunk sewer in the year 1940, should be based on a prospective population of 1,800,000, living on an area of 110 square miles, and carrying on extensive indus-
1944 tries as at present; also that a volume of storm-water, equal at least to the volume of domestic sewage, should be intercepted; that the domestic sewage will be at the average rate of 100 gallons per head per day, and a maximum rate of 150 gallons per head per day, which is also to apply to the storm-water; that the future systems of sewers will receive by unavoidable infiltration a volume of ground-water represented by an average rate of 800,000 gallons per square mile of territory, and a maximum rate of 1,200,000 gallons per square mile; and that the industrial wastes will be at the average rate of 50 gallons per head of total population per day, with a maximum rate of 90 gallons per head during the working hours of the day.

It will be noticed that the foregoing involves an average density of population of 16,364 per square mile, and it may also be assumed that each square mile of territory will have on the average 16 miles of sewers, into which the infiltration is at the average rate of 50,000 gallons per mile of sewer and the maximum rate of 75,000 gallons per mile. Reduced to gallons per capita, the ground-water infiltration thus becomes about 50 gallons per head per day for the average rate, and 75 gallons for the maximum rate. In dry weather the daily volume of sewage per capita would thus be in 1940: 100 gallons for domestic sewage, 50 gallons for ground-water, and 50 gallons for industries, total 200 gallons per head, or 360,000,000 gallons; and in wet weather would be: 100 gallons for domestic sewage, 75 gallons for ground-water, 50 gallons for industries, and 150 gallons for storm water, total 375 gallons per head, or 675,000,000 gallons. For proportioning the last section of the trunk sewer, however, the maximum rates of discharge during the working hours of wet days are to be considered, whereby the per capita rates will become: 150 gallons for domestic sewage, 75 gallons for ground water, 90 gallons for industries, and 150 gallons for storm water, total 465 gallons per head, thus making a maximum rate of 837,000,000 gallons per day or 1,295 cubic feet per second, in the year 1940. On the grade given in the aforesaid Report, the diameter of the last section above the pumping station would be about 18.0 feet when completely filled and discharging the quantity just stated.

1945 It will be observed that this maximum rate of 1,295 cubic feet per second is 2.34 times the maximum rate of 553 cubic feet per second estimated by the Passaic Valley Sewerage Commission. The latter rate consists of the following per capita rates; 150 gallons for domestic sewage 28.8 gallons for ground-water, 37.9 for industries, nothing for storm-water, total 216.7 gallons per head, or

357,365,200 gallons per day, based on a population of 1,649,440 in the year 1940. The difference between the two sets of figures *are* apparent, and require- no further explanations. I believe that these estimates are very conservative in every respect, and feel much more inclined to raise them than to reduce any of the items set forth above.

Q. Now, Mr. Kuichling, in pursuing your studies of the Passaic Valley Sewerage project, this contemplated volume of discharge into the Upper New York Bay, did you take the Upper New York Bay under consideration for study?

A. I did.

As already stated, it is proposed to discharge the sewage of the Passaic Valley Sewerage District, after partial sedimentation, into Upper New York Bay at a point near Robbins Reef Light, and it now becomes of interest to refer to the physical characteristics of that body of water. Many of these features are described in the testimony of Mr. H. De B. Parsons, a member of the New York Metropolitan Sewerage Commission, which was given in this suit on February 27, 1912, and some of the following data have been taken therefrom:

1946 Area of Upper New York Bay (pear-shaped)	20.74 sq. miles.
Length, from Battery to Ft. Wadsworth	7.0 miles
Greatest width being at Robbins Reef Light	4.4 "
Width at Battery	2.0 "
Width at Tompkinsville, near N. E. Cor. Staten Is.	2.1 "
Width at Narrows or Ft. Wadsworth	1.0 mile
Average width	2.96 miles
Greatest depth of water (opp. Governors Island)	93 feet
" " " " (opp. Ft. Wadsworth)	93 "
Depth in pool near Robbins Reef Light	75 "
Average depth of water	22.4 "
Average range of tide	4.4 "
Volume below mean low water (M. L. W.) surface	12,970,000,000 cu. ft.
Volume of tidal prism of Bay	2,541,000,000 " "
Ratio of tidal prism to volume below M. L. W	19.6 per cent.
Average tidal volume flowing out at Narrows	12,041,200,000 cu. ft.
Average tidal volume flowing in at Narrows	10,778,800,000 " "
Resultant average tidal volume flowing out at Narrows	1,262,400,000 " "

Resultant average tidal volume flowing out during the year:

a—from the Hudson River	1,087,200,000 cu. ft.
b— " " East River	80,000,000 "
c— " " Kill van Kull	88,200,000 "
d— " other marginal sources	7,000,000 "
Average depth of Bay at the Narrows	61 feet
Cross-sectional area at the Narrows	322,000 sq. ft.
Normal max. surface velocity at the Narows, ebb	2.26 ft. per sec.
" " " " " " flood	1.97 ft. per sec.
Normal duration of Ebb tide at the Narrows	6.935 solar hours.
" " " Flood " " " "	5.486 solar hours.
" " " complete tidal cycle at the Narrows	12.421 solar hours.

Salinity Observations and Proportions of Land Water and Sea Water.

Average yearly salinity of the surface at the Narrows.	37.2	per cent land water
Average seasonal salinity, 4 months—July-October inclusive	26.4	" " " "
Maximum monthly salinity at Narrows (October)	22.2	" " " "
Maximum monthly salinity at Narrows (April)	64.9	" " " "
Average yearly salinity of the surface in Lower Bay	7.6	" " " "
Average seasonal salinity 4 months, July-Oct. inclusive	6.7	" " " "
Maximum monthly salinity in Lower Bay (January)	1.3	" " " "
Minimum " " " " " (May	15.6	" " " "

From the monthly salinity and land water inflow data, it was deduced that the ebb tidal volume at the Narrows could be divided into: A—Land water which will return; (*b*) Land water which will not return; (*c*) Sea water which will return; and (*d*) Sea water
1947 which will not return; also that the flood tidal volume could be divided into: (*e*) Land water returning; (*f*) Sea water returning; and (*g*) New sea water. The normal resultant flow of the East River outward through the Narrows may be classed with sea water returning. The seasonal averages of Mr. Parsons' figures for the four months, July-October, inclusive, are as follows:

a. Land water of Ebb tidal volume that will return	2,237,500,000	cu. ft.
b. " " " " " " " " not return	755,000,000	"
c. Sea " " " " " " " return	6,682,500,000	"
d. " " " " " " " " not return	2,365,000,000	"
Total Ebb Volume	12,040,000,000	"
e. Land water returning in flood tide	2,237,500,000	"
f. Sea water returning " " "	6,682,500,000	"
g. New sea water added " " "	2,365,000,000	"
Total Flood Volume	11,285,000,000	"
Average Resultant tidal volume flowing out at Narrows (4 months)	755,000,000	"
Least resultant tidal volume flowing out at Narrows (August)	620,000,000	"

1948 It should be noted that the land-water, as indicated by the salinity, is always in excess of the run-off from the tributary drainage area, because some land-water always remains in the Bay at the end of every ebb tide. The quantity thus remaining varies with the monthly and seasonal run-off.

Drainage Area Tributary to Upper New York Bay.

The total drainage area above the Narrows, or mouth of Upper New York Bay at Fort Wadsworth, is about 14,762 square miles. This includes the water surfaces of the Hudson River, the Harlem River, the entire East River from Throgs Neck to the Upper Bay, the Kill van Kull, Newark Bay, the Passaic and Hackensack Rivers and the Upper Bay; but it does not include the watershed of the Arthur Kill. Of this total area 1,193.9 square miles are above the mouth of the Kill van Kull at the Upper Bay, and it is estimated by

the U. S. Coast & Geodetic Survey that about 16 per cent. of the drainage waters from said territory pass through the Arthur Kill into Lower New York Bay. To obtain the virtual drainage area above The Narrows, it is therefore necessary to deduct 16 per cent. of said 1,193.9 square miles, or 191.0 square miles, from the first named total, thus making the virtual area about 14,571 square miles. If the drainage area of the upper East River from Throgs Neck to the Harlem River is also deducted, the virtual area will be about 14,458 square miles.

The run-off or land-water coming from this virtual drainage area into the Upper Bay, may be estimated approximately from the rainfall and the measurements of the principal tributary rivers at points not affected by the tide. Such measurements have been made throughout a long term of years on the Mohawk, the upper Hudson and the Passaic rivers and the results thereof are submitted in my foregoing testimony on "Basic Physical Data relating to the Metropolitan and Passaic Valley Sewerage Districts." In view of the doubtful direction of the discharge of the upper East River, I consider it proper to treat the resultant flow of this portion of said tidal river as going into Long Island Sound, and hence that the virtual drainage area above the Narrows should be taken as 14,458 square miles as aforesaid. On this basis, the mean monthly flow of
1949 upland water into Upper New York Bay, expressed in cubic feet per second, will be found approximately by multiplying the monthly depth of runoff, in terms of depth in inches on the watershed, by the following factors, viz: 12,541 for a month of 31 days; 12,959 for a month of 30 days, and 13,884 for a month of 28 days.

Q. What studies have you given to that subject of land water and runoff flowing into the Upper Bay?

A. From the data mentioned, the mean annual depth of runoff from the said virtual drainage area of the Upper Bay (14,458 sq. miles) is 23.78 inches, corresponding to an average flow of 25,328 cubic feet per second. During a complete tidal cycle of 12,421 solar hours, or 44,715 seconds, the volume of upland water will thus be 1,132,600,000 cubic feet, and by adding thereto 80,000,000 cubic feet for the estimated average resultant tidal discharge of the lower East River into the Bay, the sum will be 1,212,600,000 cubic feet, which agrees fairly well with the figures previously given by Mr. Parsons. It is very probable that a slightly different drainage area and average annual depth of runoff were adopted by him, which would account for his somewhat larger resultant tidal outflow.

The least dry-season runoff to be expected every 8 or 10 years is as follows: In a single month (September) 0.37 inch, corresponding to a resultant tidal outflow of 294,400,000 cubic feet; in two consecutive months (August and September) 0.94 inch, corresponding to a resultant tidal outflow of 348,000,000 cubic feet; and in three consecutive months (August, September and October) 1.26 inches, corresponding to a resultant tidal outflow of 318,000,000 cubic feet; in each case 80,000,000 having been added for the resultant tidal outflow of the lower East River. It is these low figures that must be considered in dealing with the sewage of the Passaic

Valley District, instead of the lowest average monthly runoff for a series of years, since the latter would be 0.96 inch for September or 2.6 times the aforesaid occasional minimum for a single month, 1.90 inches for August and September, and 3.26 inches for August, September and October.

Salinometer observations for such very low runoffs as were just mentioned are not available, and under these conditions the quantity of new sea water brought into the Upper Bay by the flood tide
1950 will be much less than the aforesaid seasonal average (2,365,000,000 cu. ft.) during the four months, July-October. According to the figures given by Mr. Parsons, the average volume of "new" sea water entering the Upper Bay during each normal flood tide in August is 1,520,000,000 cu. ft. while the volume of returning sea water is 6,980,000,000 cu. ft., and that of returning land water is 2,840,000,000 cubic feet, the total volume of the flood tide being 11,340,000,000 cubic feet. The resultant outflow through the Narrows, in this case, is about 700,000,000 cubic feet corresponding to an estimated volume of 620,000,000 cubic feet of land water and 80,000,000 cubic feet of mixed land and sea water from the East River. On the other hand, when the aforesaid minimum runoff of 0.37-inch in September of some future year is experienced, the resultant outflow of 294,400,000 cubic feet will correspond to an incoming flood volume of 11,745,600,000 cubic feet of which less than 10 per cent. may be "new" sea water.

Q. What study did you give to the quality of the water in the Upper New York Bay?

A. It must not be understood that either the land water or the sea water in the Upper Bay is clean at any time. The waters of the Hudson, Harlem, East, Passaic and Hackensack Rivers, as well as those of Newark Bay and Lower New York Bay, are already more or less polluted, so that the tidal circulation in the Upper Bay is essentially an oscillation of waters which have been mixed with sewage. According to the "Basic Physical Data" previously cited, the total population in 1910 (within the limits of the Metropolitan Sewerage District) that was discharging its sewage directly into the Hudson, Harlem and East Rivers, the Kill van Kull, and the Upper Bay was 5,029,477; and the total population in 1910 (within the same limits) that was discharging its sewage directly into the Passaic and Hackensack rivers and Newark Bay, including 122,036 persons in Elizabeth and contiguous communities served by an outlet sewer emptying very near the junction of Arthur Kill and Newark Bay, was 929,270. Remembering that about 84 per cent. of the outflow from Newark Bay goes into Upper New York Bay, and taking the same percentage of the last-named population tributary to Newark Bay, this number will be 780,587; hence it can be said that
1951 the sewage of about 5,810,000 people, within the limits of said District in 1910, found its way more or less directly into the Upper Bay.

If it be assumed conservatively that the sewage of this great aggregation of industrial people is produced at the rate of 150 gallons per head per day, its volume will be 871,500,000 gallons per day, and the average rate of outflow will be 1,348.4 cubic feet per second. In

a tidal cycle of 12,421 hours or 44,715 second-, the volume of sewage will thus be about 60,294,000 cubic feet in the year 1910, while in a time of severe drought the volume of "new" sea water brought into the Upper Bay by the preceding flood tide may be only about 1,200,000,000 cubic feet. Of the nature of the 214,400,000 cubic feet of inflowing land water at such a time, little need be said, as it will obviously be polluted to considerable extent; and of the purity of the so-called "new" sea-water very little is known, since the salinometer observations afford no information regarding organic impurities, and indicate only the quantity of mineral salts contained in the water.

Q. Did you take the float observations into consideration in your studies of the Upper New York Bay?

A. I did. The float observations of the present and former Metropolitan Sewerage Commissions enable an approximate judgment to be formed concerning the quality of the water in the Upper Bay. A summary of these experiments, appended to the aforesaid "Basic Physical Data" shows that in this body of water the ebb current continues on the average for 6.07 hours, during which a float travels 9.15 miles with a mean velocity of 1.51 miles per hour; also that the flood current continues on the average for 5.48 hours, during which a float travels 5.39 miles at a mean velocity of 0.98 mile per hour. The difference between these two distances traveled is 3.76 miles; and as the distance from the Battery to the Narrows is 7.0 miles in a straight line, and is probably 7.5 miles by the course of the ebb current, it follows that a floating object starting at the Battery at the beginning of ebb, will oscillate forward and back in the Upper Bay at least 24 hours before it finally remains below the Narrows. Such movement, however, is often retarded by wind action; hence it will be safe to consider that the period of
1952 oscillation of a floating object in the Bay is about 36 hours, during which time a volume of about 180,900,000 cubic feet of sewage was probably discharged directly into the Bay and its tributaries in the year 1910; and with a yearly average growth of population of about 3.5 per cent., this volume would be about 193,600,000 cubic feet in the year 1912.

The continual mixing of so large a volume of sewage with less than 20 times its volume of "new" sea water brought into the Bay by flood tides, renders the purity or cleanliness of this water very questionable in times of severe drought, as the rate of natural self-purification in the lower Bay and open ocean is not definitely known. Some inferences as to this process may be drawn from the contents of dissolved oxygen in the water of the Lower Bay, but it must be remembered that when this water has been rendered markedly impure by organic matters that are not readily oxidized, it may still exhibit a large degree of saturation with dissolved oxygen, as well as a high salinity. Unfortunately, complete chemical analyses of this water do not seem to be available, and similarly, no studies of its plankton have been made public. In the absence of such important chemical and biological data, the inference is justifiable that the "new" sea water is not now pure, and that it will continue to deteriorate in quality un-

der existing conditions of sewage discharge. It must also be borne in mind that the radio of "new" sea water to sewage is steadily reducing, and that the 20-fold proportion computed above for a time of severe drought has already ceased to exist.

Q. In your studies of the waters of Upper New York Bay, did you take the bacterial contents of the harbor waters under your study?

A. I did. A useful index of the degree to which the waters of the harbor are polluted by sewage is afforded by the number and nature of the bacteria contained in samples thereof. Many determinations of this kind were made in 1909 at various depths by the Metropolitan Sewerage Commission, and it was found that larger numbers existed in the water which flowed out during ebb, than in that which flowed into the harbor during flood; also that the numbers were higher near the surface than near the bottom. The smallest number in a cubic centimeter was 35, this being in a sample of ocean water at a depth of 150 feet ten miles off Long Branch. In Long Island Sound
1953 the average of all samples was 375. The highest numbers were found in the Passaic River at Newark N. J. where the average number per cubic centimeter was 141,000 during ebb and 65,000 during flood tide. A comprehensive view of the bacterial contents of the water at different localities will be gained from the following Table taken from the Report of the Metropolitan Sewerage Commission dated April 30, 1910, page 395.

Table Showing Average Number of Bacteria Per C. C. in the Harbor Waters During Ebb and Flood Tides, March 26 to October 5, 1909.

Locality.	Ebb tide.		Flood tide.	
	No. of analyses.	Bacteria per C. C.	No. of analyses.	Bacteria per C. C.
Atlantic Ocean, 10 miles off Long Branch	...	....	4	120
Lower New York Bay	119	1,400	111	1,200
The Narrows	27	6,700	22	2,500
Arthur Kill	12	7,400	7	350
Kill van Kull	63	6,700	38	5,400
Newark Bay	21	9,000	24	6,000
Passaic River at Newark	4	141,000	4	65,000
Upper New York Bay	73	16,000	19	10,000
Hudson River, below Spuyten Duyvil	85	7,700	79	4,800
Hudson River, above Spuyten Duyvil	23	6,500	32	6,000
Harlem River	31	16,000	27	15,000
East River below Hell Gate	67	10,000	65	5,600
East River above Hell Gate	15	1,800	18	4,700
Long Island Sound	21	540	25	255

Q. Did you take under your consideration for your study the harbor deposits, the mud on the bottom of the harbor?

A. I did. The quality of the water in New York Harbor is necessarily affected in some degree by the character of the deposits found on the bottom. Prior to 1908, about 700 samples of such deposits were examined chemically and bacteriologically by the Metropolitan Sewerage Commission, but the chemical work seems to have been limited mainly to the determination of the loss on ignition, on the presumption that this loss would indicate correctly the proportion of solid matter derived from sewage. Subsequently it was con-
1954 sidered that more exact information concerning the character of the mud should be obtained through microscopical examinations, and hence the details of the first investigations were not published. Reference to this work, however is made on 415 of said Commission's report made in 1910, where it is briefly stated that the number of bacteria in one gram of mud ranged from 7,500 to 26,000,000, and that in one case a sample containing 400,000 bacteria was found close to another sample containing 19,000,000; also that the test for loss on ignition did little to make it plain whether the deposits were composed of sewage matters or not, and that it might easily be influenced by the presence of sea weed, bodies of marine animals, etc.

Q. Were you here at the hearing at which Mr. Robert M. Hoyt, the Health Officer of Princeton, New Jersey, testified?

A. I was not present at that hearing.

Q. Proceed.

A. After January 1, 1908, the examination of deposits in the harbor was limited to the following items:—observations of color, odor and apparent composition of the sample when collected, and a search for microscopic debris which had probably come from sewage. (Report of Metropolitan Sewerage Commission, 1910, page 422.) On page 425 of said report it is stated that 1,100 such examinations had been made, which showed that a large part of the bottom of New York Harbor was polluted with deposits of solid matter from sewage; and on pp. 79-80 of the same report these deposits are described as follows:—"Sewage solids accumulate to some extent upon the harbor bottom. Practically the whole of the bottom of Upper New York Bay is covered with black, ill-smelling mud in which particles of sewage origin are distinguishable. In places these deposits have been found to attain a depth of over ten feet. In the lower Bay deposits occur more often in the main channels than elsewhere."

The presence of so much decomposable organic matter on the bottom, as is clearly indicated by the bacterial, chemical and microscopical examinations mentioned above, cannot fail to impair the quality of the overlying water. The gases and soluble products of decomposition are absorbed by the water, and to maintain
1955 the active processes of decomposition, oxygen is abstracted from the quantity thereof which is dissolved in the water. Sewage, however, contains much putrescible organic matter, in both true and collodial solution, which is readily oxidized either directly in chemical manner, or indirectly through the action of bacteria which

require a definite supply of oxygen. A large proportion of the finely divided organic solids is eaten by microscopic animals which live suspended in the water when the dissolved oxygen is not exhausted, and the remainder of the sewage solids tend to settle on the bottom where they will be attacked by another class of organisms that are also more or less dependent on such oxygen. The result of the sewage pollution is that the harbor waters contain much less dissolved oxygen than clean water of the same salinity, and that this undesirable condition of the water is largely promoted by the deposits of foul mud. Ample evidence of this kind is found in the Fifth Report of the Royal Commission on Sewage Disposal, Appendix VI, pp. 129-136.

Q. Now, as to the quantity of dissolved oxygen in the harbor waters, what studies have you given to that?

A. I examined all the data that have been rendered available by the Metropolitan Sewerage Commission. In recent years the amount of dissolved oxygen contained in a body of water has been regarded as the most reliable index of its degree of pollution by decomposable organic matter. Clean water has the property of absorbing a certain quantity of oxygen from the atmosphere, depending on the temperature and barometric pressure; and when these two factors remain constant, this quantity will depend on the amount of mineral matter dissolved in the water. When fully saturated with such oxygen, the quantity contained in different mixtures of distilled water and seawater, and also at different temperatures, is given in the following table:

1956 *Table Showing Contents of Dissolved Oxygen, Expressed in Cubic Centimeters Per Litre at Saturation, of Different Mixtures of Distilled and Sea Water at Different Temperatures, the Barometric Pressure Remaining Uniformly at 760MM.*

Compiled from Fifth Report of Royal Commission on Sewage Disposal, Appendix VI, 1908, Page 59.

Temperature.		Percentage of distilled water in the mixture.						
C°.	F°.	0.	10.	20.	30.	40.	50.	100.
10	50	6.45	6.61	6.76	6.92	7.07	7.23	8.00
12	53.6	6.19	6.34	6.48	6.63	6.78	6.93	7.66
14	57.2	5.94	6.08	6.22	6.36	6.50	6.65	7.35
16	60.8	5.72	5.85	5.99	6.12	6.26	6.39	7.06
18	64.4	5.51	5.64	5.76	5.89	6.02	6.15	6.78
20	68	5.31	5.43	5.55	5.68	5.80	5.92	6.53
22	71.6	5.13	5.25	5.36	5.48	5.60	5.72	6.30
24	75.2	4.95	5.06	5.17	5.29	5.40	5.51	6.07
26	78.8	4.79	4.90	5.01	5.11	5.22	5.33	5.87
28	82.4	4.64	4.74	4.85	4.95	5.06	5.16	5.68
30	86	4.50	4.60	4.70	4.80	4.90	5.00	5.495

It may be noted that the volumes of oxygen given in the above table refer uniformly to the standard volume of the gas when at the temperature 0°C. This is done in order to compute its weight readily. At 0°C., one cubic centimeter of oxygen weighs 1.429 milligrams; hence the products obtained by multiplying said volumes by 1.428 will represent the weight of the dissolved oxygen in milligrams per litre, or parts by weight per million. The figures were originally given by Dittmar in Vol. 1 of "The Challenger" Reports, page 160, and relate to sea water containing about 20,500 parts by weight of chlorine per million. Off the American coast the chlorine contents of Atlantic Ocean are somewhat less, being about 17,600 off Cape Cod, 17,400 off Nantucket and 18,500 off Long Island and New Jersey at such a distance as not to be affected by fresh water from the land. (See Report of Burr, Hering — Freeman on additional Water Supply for the City of New York, 1904, pp. 517-528.)

Q. This is in corroboration of the views that you have expressed?

A. Yes. As previously stated, the salinity of the water in New York Harbor varies greatly with the season and locality. In the Ambrose channel of the Lower Bay, the percentage of land water at the surface ranges from 1.3 in January to 15.6 in May and 6.0 in October, while at Robbins Reef in the Upper Bay it ranges from a maximum of 56.1 in April to a minimum of 18.3 in September.

1957 Much attention has been given by the Metropolitan Sewerage Commission to determining the quantity of dissolved oxygen in the water of different portions of New York Harbor, hundreds of observations having been made in 1909 and a far greater number in 1911. A summary of the observations made in 1909 is given in the published Report of said Commission dated April 30, 1910, pp. 412-413, and a similar summary has been made for those of 1911.

Q. Which are in evidence in this case?

A. Yes, sir. And I have a table showing the average amount of dissolved oxygen expressed in per cent. of saturation in the water on ebb and flood tide at several different localities in New York Harbor in 1909 and 1911.

Q. A table compiled by whom?

A. Compiled by myself.

Q. State the contents of that table?

A. The table is as follows:

Table Showing Average Amount of Dissolved Oxygen Expressed in per Cent. of Saturation in the Water on Ebb and Flood Tides at Several Different Localities in New York Harbor in 1909 & 1911.

Locality.	Ebb currents.		Flood currents.	
	1909.	1911.	1909.	1911.
Hudson River, Lower part.....	66	54	76	58
East River, Lower part.....	60	53	69	57
Kill van Kull.....	78	74	82	76
Newark Bay, Lower part.....	74	67	78	61
Upper Bay	64	72	78	75
The Narrows	74	74	92	82

The figures indicate clearly that after an interval of two years the waters of New York Harbor have suffered an appreciable loss in contents of dissolved oxygen, and have therefore become more strongly polluted with putrescible organic matter. The case of the Upper Bay on Ebb tide is apparently an exception to this statement, but the discrepancy is doubtless due to temporary differences in the condition of the water, as well as to difference in date, location, etc. It is inconceivable that an improvement should have taken place, owing to the greater volume of sewage due to increase of population in two years. The figures also indicate that the waters are approaching a condition that is distinctly unfavorable for the maintenance of major fish life, and that the discharge of the large volume of sewage from the Passaic Valley Sewerage District directly into
1958 the Upper Bay near Robbins Reef Light, will result in a further depletion of the amount of dissolved oxygen which will probably render the water malodorous, especially in time of drought.

Another feature is the rate at which oxygen is absorbed or dissolved by water from the atmosphere under natural conditions. On this subject little information is available. Dibdin seems to have made the first extensive experiments to ascertain such rate in 1894, and a description thereof is given in his book entitled, "The Purification of Sewage and Water," 3rd Edition, London, 1903, pp. 280-288. From the data there given, I have deduced the following simple formulas for computing the approximate percentage of saturation (y) with dissolved oxygen attained by a mass of completely deaerated fresh (land) water after (x) hours of quiet exposure to the atmosphere:—

1. From x=1 to 12 hours, $$y=\frac{(86\ X)}{(X+6.8)}$$

2. From x=12 to 60 hours $$y=\frac{(166\ X)}{(X+7)}$$

In brief tabular form, Dibdin's results are as follows:—

For x=	1	2	3	4	6	8	10	12	hours
y=	11	20	26	32	40	46.5	51	55	per cent;
For x=	12	18	24	30	36	42	48	54	hours,
y=	55	62.3	67.8	73	76.6	79.7	82.6	85.3	per cent

A number of similar experiments were made more recently by Adeney and Letts, and are described in Appendix VI of the Fifth Report of the Royal Commission on Sewage Disposal, London, 1908. They were made with both distilled water and sea-water collected in Dublin Bay which contained 19,570 parts of chlorine per million; but as the absorption of oxygen was determined only after comparatively long periods of exposure, ranging from 12 to 42 hours and more, the true rates of absorptiin from hour to hour

were not found. The practical conclusions drawn from their experiments (l. c. p. 65) were as follows:—The volume of oxygen transmitted from the air in calm weather to a depth of at
1959 least 6 feet of de-aerated water, expressed in cubic centimeters per litre in one hour, is 0.08 for sea water; 0.03 for fresh (or distilled) water; 0.068 for a mixture of 3 parts sea-water to 1 part fresh-water; 0.063 for a mixture of 2 parts sea water to 1 part fresh water; 0.055 for a mixture of 1 part sea-water to 1 part fresh water; 0.047 for a mixture of 1 part sea-water to 2 parts fresh water; 0.043 for a mixture of 1 part sea-water to 3 parts fresh-water.

It should be noted that the temperature of the water to which these figures apply is not given, but as it was from 12° to 18° C. during the experiments, it may be presumed that the figures refer to an average temperature of 15° C. or 59° F. The same remark also applies to Dibdin's data. To compare the latter with the average hourly rate of 0.03 c. c. per litre given by Adeney & Letts, a definite period of time must be assumed as well as the temperature, so as to have the saturation limit for fresh distilled water. This limit is 7.2 c. c. per litre for a temperature of 15° C., and the period of time may be assumed at 24 hours for water that has been completely de-aerated. According to the said hourly rate of transmission this water would absorb in 24 hours only 0.72 c. c. per litre, corresponding to 10 per cent. of saturation, while according to Dibdin's table it would be at 67.8 per cent. of saturation.

The discrepancy between the two sets of data thus appears to be very great, but much of it disappears on close scrutiny of the language used. It is very likely that the said hourly rate of transmission refers only to the volume of oxygen that is found in a thin stratum of water about 6 feet below the surface, while Dibdin's figures presumably refer to the entire amount in a surface stratum about 1.5 feet thick, which absorbs oxygen much more rapidly than the lower strata. Thus is one experiment with distilled water, Adeney & Letts obtained an average rate of 0.39 c. c. per litre per hour during a period of 12 hours in a surface stratum about eight inches thick, whereby 65 per cent. of saturation would be obtained, whereas Dibdin's table gives 55 per cent. saturation in the same period. On this basis of consideration, the data becomes far
1960 more concordant. There is, however, much need for more extensive and accurate experimentation in this direction.

Q. Did you devote any study to the conditions of pollution of the shores of the Upper Bay?

A. I did. In March and April 1906, the New York Bay Pollution Commission caused a careful inspection to be made of the shores of the Upper and Lower Bay, for the purpose of ascertaining to what extent they were polluted by sewage. This inspection was performed by Dr. Payne B. Parsons——

Q. His report is an exhibit in this case?

A. I believe it is, yes, sir. This inspection was performed by Dr. Payne B. Parsons who walked along the shores and noted their

condition; and his report is printed on pp. 33-43 of the report of said Commission made in 1906. It appears therefrom that all the shores of the Upper Bay and Kill van Kull were more or less polluted by sewage, scum and oily sleek in addition to garbage and other refuse, and that the pollution was strongest in the immediate vicinity of large sewer outlets. It was also found that both shores of the Lower Bay where similarly polluted for a considerable distance below the Narrows.

These observations are of the utmost significance in estimating the effect of the discharge of large volumes of sewage into the Upper Bay, and are far more useful than the results of experiments made with floats submerged more or less deeply below the surface. The latter are influenced much less by the wind than smaller objects which float on the surface and traverse shallows at the shores. In many cases also, sewage pollution of beaches was found at long distances from the mouths of the nearest outlet sewers, and it is safe to say that if the examination had been made in the autumn, when there is no flushing action of freshets in the Hudson River by a much longer duration of ebb currents, the pollution would have been found more extensive than as reported.

Q. Have you taken into consideration in your studies of the Upper Bay and the tidal waters, the float observations, that are in evidence, marked as exhibits in this cause, and the tidal currents in the Upper Bay?

A. I have. Reference has already been made to the float observations in the Upper Bay and adjacent waters, as given in the aforesaid "Basic Physical Data", and a few additional remarks
1960½ on this subject are now pertinent. The courses followed by the floats placed in the Upper Bay are shown on the charts marked Exhibit No. 4-8 inclusive, 10, 11, 59, 61, 62, 74, 76, 78, 81 inclusive. They were made in February, March, April and July, 1907, September and October, 1908, and November and December, 1909. Nineteen fairly complete courses during ebb current, and fourteen similar ones during flood current were closely observed and platted. The results are essentially as follows:

Designation.	Ebb current.			Flood current.		
	Average.	Max.	Min.	Average.	Max.	Min.
Duration of current in solar hours	6.067	8.750	4.917	5.483	6.833	4.167
Distance traveled by float in miles	9.15	16.26	5.20	5.39	9.14	2.70
Mean velocity in miles per hour	1.51	2.29	0.93	0.98	1.14	0.65

These figures indicate that there is much variation in the duration and average intensity of the tidal currents, and the data show that such variations are of frequent occurrence in single months. Usually a day or two after both new and full moon, or twice in each lunar month, the tides rise higher and fall lower than at other times, and are then called spring tides; also one or two days after the moon is in her "quarters", or twice in each lunar month they

both rise and fall less than at other times, and are then called neap tides. They are also greatly affected by the winds and storms. Thus during the very stormy period early in January 1912, the conditions were such that there was no appreciable tidal variation in the surface of the Upper Bay for about 48 hours, although the average range of the tide is 4.4 feet. The time of "highwater" at any place is generally 2 or 3 hours after the moon has passed over either the upper or lower meridian. "Slack water" is the term used to express the condition that tidal currents in either direction have ceased, and the time of its occurrence is not coincident with that of high or low water. In the lower part of the Hudson River, slack water generally ensues about three hours after high or low water.

From a study of the tide tables published by the U. S. Coast & Geodetic Survey for the use of navigators, Mr. Kenneth Allen, Engineer of the Metropolitan Sewerage Commission——

1961 Q. Who has testified to the facts in this case?

A. Yes, sir. Mr. Kenneth Allen, Engineer of the Metropolitan Sewerage Commission recently deduced the following data relating to the normal times of high and low water and slack water in New York harbor, the figures denoting solar hours after the moon's transit or passage over the meridian of the place indicated:

Locality.	High water.	Slack High water.	Low water.	Slack Low water
The Narrows	7.683	9.583	1.633	3.009
Governor's Island	8.067	10.044	2.083	4.750

According to these figures, the normal period from low to high water on flood tide is 6.050 hours at the Narrows, and 5.984 hours at Governors Island; while the normal duration of flood currents from slack low water to slack high water is 6.583 hours at the Narrows and 5.294 hours at Governor's Island. As the tidal cycle is 12 lunar hours of 12.421 solar hours, the normal period from high to low water on ebb tide is 6.371 hours at the Narrows, and 6.437 hours at Governor's Island; while the normal duration of ebb currents from slack high water to slack low water is 5.838 hours at the Narrows, and 7.127 hours at Governors Island.

An inquiry on the subject addressed by me on February 2, 1912, to the U. S. Coast & Geodetic Survey Office, elicited the following reply, dated February 17, 1912:—"Most of the current observations of this Survey in New York harbor were made from ships at anchor, and are therefore not directly available for answers to your questions. From this data, however, the times and distances which free floats would probably travel if placed in the harbor at the points given in your letter have been estimated as follows (the floats being dropped or started at high water on flood or low water on ebb, and also at time of slack water:

1962 Locality.	Tidal current.	At high or low water. Hours.	Miles.	At slack water. Hours.	Miles.
Mouth of Hudson River	Flood (N.)	2.75	2.8	6	7
" " " "	Ebb (S.)	2.50	3.2	6	10
Mouth of East River	Flood (N.)	2.00	3.0	6	12
" " " "	Ebb (S.)	2.50	3.2	6	10
Middle of Upper Bay	Flood (N.)	2.25	2.0	6.5	8
" " " "	Ebb (S.)	2.50	2.5	6.0	10
The Narrows	Flood (N.)	2.00	2.0	6.5	8
" "	Ebb (S.)	2.50	3.0	6.0	9
Lower New York Bay	Flood (N. W.)	1.50	0.9	6	7
" " " "	Ebb (S. E.)	1.50	1.2	6	8

The above may be considered as approximate average values for floats dropped in middle of channel. The distances may vary as much as 25 per centum from the average values at the time of the spring or neap tides. The wind, and also the amount of fresh water coming down the rivers, will have an effect on the times and distances the floats would travel. * * *

(Signed) O. H. TITTMANN,
Superintendent."

The figures in the second column of the foregoing table indicate that in the middle of the Upper Bay the flood current continues to flow northerly for 2.25 hours after high water has been attained, while the ebb current continues to flow southerly for 2.50 hours after low water has been attained; those in the third column indicate that a floating object starting from the said middle point of the Upper Bay at high water will travel with the flood current 2 miles northerly, and when started at low water, it will travel with the ebb current 2.5 miles southerly; those in the fourth column indicate that at said middle point, the flood currents persist for 6.5 hours, while the ebb currents continue for 6.0 hours; and those in the fifth column indicate that a floating object, starting at slack low water at said middle point, will travel northerly with the flood current a distance of 8 miles, and when starting at slack high water it will travel southerly with the ebb current a distance of 10 miles; all these figures being understood to be averages. Similarly for the other localities.

It is very probable that the foregoing figures given by the
1963 U. S. Coast & Geodetic Survey are based on many more observations than the limited number of floats set out by the Metropolitan Sewerage Commission, referred to above, and hence they may be accepted as representing the prevalent conditions of tidal currents in the Upper Bay better than the said float experiments. It will therefore be seen that a floating particle of sewage matter, starting at slack water at the middle of the Upper Bay, has on the average a resultant movement of (10—8)=2 miles southerly towards the Narrows in each tidal period of 12.42 hours; and as the distance from said middle point to the Narrows is about 3.75 miles, the floating particles will accordingly oscillate back and forth for two tidal periods before it remains permanently below the Narrows. It must, however, be remembered that this computation is based on the assumption that the particle keeps "in the middle of the channel," or

travels always with the swiftest portions of the two currents; also that particles floating near the shores travel much more slowly than those in mid-stream; hence it may safely be estimated that on the average such particles will oscillate in the Upper Bay during at least three tidal periods before passing finally below the Narrows.

Q. Mr. Kuichling, in studying the Upper Bay, did you devote any part of your studies to the topography or contour of the bottom?

A. I did. To obtain a thorough knowledge of the direction, intensity and duration of the tidal currents at all times in the Upper Bay——

Q. Did you prepare a map showing the contour of the harbor bottom?

A. I did.

Q. Have you that map with you?

A. I have, sir.

Q. Who prepared this map?

A. I prepared it partly myself and the rest of the work was done under my immediate supervision, by my assistants.

Q. What data did you use—describe what data you used in preparing that map?

A. I used a chart published by the United States Coast & Geodetic Survey, Washington, in February 1910, on a scale of 1 to 40,000 or 1 inch equal to 3,333⅓ feet, or 1,584 inches is 1 mile. This chart showed on the water surfaces a vast number of figures
1964 indicating the depth of the water below mean low water level. Instead of copying these figures, I drew lines of equal depths through the points indicated by the position of the figures, thus making contours or lines of equal depths below mean low water level. These different depths are indicated on the map by lines and figures, showing the depth of water considered.

Q. What colors are those lines?

A. They are white lines upon a blue ground. The original is a tracing, on which they were black lines upon a transparent ground.

Q. Have you compared that blue print in front of you with the original tracing?

A. I have.

Q. And how does it compare?

A. It is an exact copy, a photographic copy.

Mr. O'Sullivan: I offer that map or chart prepared and described by this witness in evidence and ask that it be marked Complainants' Exhibit No. 126 in evidence.

Cross-examination by Mr. Riker:

Q. What was the foundation for this chart?

A. The foundation was a chart published in February 1910 by the U. S. *States* Coast and Geodetic Survey, sent to me from them at my request.

Q. And on that you made a tracing?

A. From that I made a tracing, laying the tracing cloth directly over this chart, I traced the outlines of the surface and the islands and the rivers, and on this tracing I drew the contour at lines of

equal depth of the series of depths as shown. The four contours of depths of 6 feet, 12 feet, 18 feet and 24 feet were indicated on this chart itself, on the original chart itself, by line and shade, or stippled areas, and the remainder, below a depth of 24 feet I have drawn on myself.

Q. What you have done is a little mechanical drawing in uniting the points of equal depths by lines; that is all this is, is it not?

A. Yes, sir.

Mr. Riker: I object to the offer on the ground that it is immaterial and irrelevant and contains no original data.

The Commissioner: Note the objection.

Received and marked Complainants' Exhibit No. 126.

Marked Complainants' Exhibit No. 126.

1965 Direct examination by Mr. O'Sullivan (resumed):

Q. Now, apart from the preparation of this map or chart showing the harbor contours or topography of the harbor bottom, what other studies did you give the subject of the topography or contour of the harbor?

A. I studied the different depths shown at different points in the harbor and so forth. From this chart, I wanted to ascertain the direction of the principal currents in the harbor, the points of greatest depth, the channels through which the currents would flow and those lines in which the velocity of the current would be greatest.

Q. Do the pockets, as shown on this influence the currents?

A. Yes. They influence the current both in direction and in intensity. They produce a change of direction from horizontal to vertical, from vertical back again to horizontal, and create eddies or swirls of the water.

Q. What other studies did you engage in on this subject?

A. An examination of this map shows the existence of three principal depressions in the bottom of the Upper Bay; the first one being located 0.41 miles westerly from Governors Island and approximately in the southerly prolongation of the axis of the Hudson River; the second being about 0.47 mile easterly from Robbins Reef Light and near the boundary line between the States of New York and New Jersey; and the third being in the Narrows. The maximum depth in the first depression is 93 feet; in the second it is 75 feet; and in the third, on a line between Fort Wadsworth and Fort Lafayette, it is 93 feet, while at a point 0.91 mile southerly from said line it is 116 feet. All of these depressions are comparatively long and narrow, the lengths and maximum widths of the oblong areas enclosed by the 60 feet contours being approximately as follows:

	Length	Max. Width
1. West of Governors Island.....	1.50 miles	0.25 mile
2. East of Robbins Reef.....	1.01 "	0.21 "
3. Narrows and Lower Bay.....	4.00 "	0.63 "
4. 0.5 mi. E. of Tompkinsville.....	0.38 "	0.08 "

The 60 ft. contour does not appear at any other locality in the Upper Bay, nor in the Lower Bay until reaching a small
1966 isolated depression 0.65 mile north of Sandy Hook, and the beginning of the main outlet into the ocean at a point 4.4 miles East from Sandy Hook; but it is found in both the Hudson and East rivers a little north of the Battery and also farther up stream. In the channel on the east side of Governors Island the maximum depth is 44 feet; in the Kill van Kull it is 50 feet, near the mouth; in Newark Bay it is 33 feet in a single depression a little north of the C. R. R. of N. J. bridge; in the northern portion of the Arthur Kill it is 24 feet, and in the southern portion it is 48 feet in a depression opposite Tottenville.

In regard to shallow water, it may suffice to state that the 12 feet contour follows the line of the west shore of the Hudson River southerly to Robbins Reef Light, and thence runs westerly to Constable Hook and along the north shore of the Kill van Kull to and up the Newark Bay. Between this contour and the New Jersey shore on the west side of Upper New York Bay, is an area of about 6.93 square miles of shallow water, having an average depth of only 6 feet at low tide; its length is about 4.5 miles and its greatest width is 2.5 miles. On the east side of the Upper Bay, the 12 feet contour enclosed an irregular area 0.79 mile long and 0.22 mile wide, located south of Governors Island and West of the indentation called Gowanus Bay. South of Kill van Kull to Fort Wadsworth on the west side and south of Gowanus Bay to Fort Lafayette on the east side, the 12 ft. contour is at most 0.15 mile from the shore.

Below Fort Wadsworth the same contour forms a loop 3.50 miles long in a southerly direction with a greatest width of 0.80 mile; and along the Staten Island shore, the location of said contour gradually increases from 0.2 mile to 1.25 miles at the Great Kills peninsula. At Sequine Point, 3.5 miles beyond this peninsula, the 12 ft. contour is close to the shore, and continues thence westerly along Staten Island, Arthur Kill and Raritan River; it then returns at an average distance of 0.65 mile from the Staten Island shore to a point 0.32 mile south of the aforesaid Sequine Point, where it turns south, thus forming the sides of the principal channel for carrying the tidal waters of Arthur Kill and Raritan
1967 River to and from the Lower Bay. On the eastern side below Fort Lafayette, the 12 feet contour is about 0.2 mile from shore to Unionville where it turns southwesterly and passes around the west end of Coney Island, thereby causing a large area of shallow water in the southern portion of Gravesend Bay. South of Coney Island, the same contour encloses numerous detached areas until the Ambrose Channel is reached.

The topography of the bottom shows very plainly a main channel through both the Hudson and East Rivers, the latter being north of Governors Island and uniting with the former in the first principal depression described above; thence a single main channel of relatively small width to the second depression near Robbins Reef Light, and continuing to a point about a mile north of Fort Wads-

worth, where it unites with a minor relatively narrow channel, only about 30 feet deep, running nearly parallel to the Brooklyn shore; thence a gradually widening channel through the Narrows and Lower Bay to the Ambrose Channel. Before reaching the latter, however, a narrow minor channel about 30 feet deep continues southerly to a point 1.6 miles west of Sandy Hook, where it unites with the wide main outlet channel for the waters of the Raritan River and Arthur Kill, which begins near Point Sequine on Staten Island, and has a depth ranging from 18 feet to 30 feet.

It is a fundamental principle of hydraulics that the frictional resistances to the motion of water are less in a deep channel than in a shallow one of the same width, and hence it may be considered that the swiftest tidal currents will be found in the main channels described above, also that a large proportion of the tidal water passes through these channels. But it must likewise be remembered that there is always a certain amount of lateral flow from and into the main channels, according to whether the tide is in flood or in ebb, whereby the waters of the deep and shallow portion of the bay will be more or less commingled; and especially will this be the case with the waters at the surface, which are subject to the action of the winds. A further tendency to mingle in the

1968 Upper Bay is due to the presence of a considerable volume of land-water brought in by the Hudson River and the Kill van Kull.

This land-water is lighter than the sea water, but the salts in solution in the latter tend constantly to become more dilute, thus necessarily causing minute currents between the two kinds of water. The rate of such diffusion, however, depends on a variety of conditions, such as the nature of the substances in solution, the temperature, the physical currents, the quantity of dissolved matter in both waters, etc.; thus the rate is materially reduced if a portion of the same diffusing substance be already present in the land-water. Sodium Chloride diffuses 3 times more rapidly than sugar and magnesium sulphate, 21 times more rapidly than albumen, and nearly 43 times faster than caramel. The last two substances, along with starch, dextrine, gelatine, glue, gum, etc., are characterized by the mucilaginous nature of their hydrates, and they are called colloids, in contradistinction to the far more easily diffusible crystalloid substances.

Returning to the consideration of the principal currents in the Upper Bay, the following conclusions are reached by me: 1. That surface drifts from the ebb current of the Hudson River will flow into the extensive shallow area west of Ellis and Liberty Islands. 2. That surface drifts from the ebb currents of both the Hudson River and the Kill van Kull, will flow into the extensive shallow area between Robbins Reef Light and Bayonne. 3. That surface drifts from the ebb current will flow to the Staten Island shore from New Brighton to Fort Wadsworth. 4. That surface drifts from the ebb current in the minor channel parallel wo the Brooklyn shore will flow into Gowanus Bay and to the shore below. 5. That surface drifts from the ebb current below the Narrows will flow into

Gravesend Bay, and to a lesser extent to the Staten Island shore south of Fort Wadsworth. All of these surface drifts will be repeated on the flood current, and their magnitude will depend largely on the wind.

Q. Mr. Kuichling, did you take opportunity to study the prevalent direction and velocity of the winds in the Upper Bay in this line of study?

1969 A. A table showing the direction, duration, and velocity of the wind in the vicinity of the Battery, during the months of June, July, August and September for the five years 1907-1911 inclusive has been compiled by Mr. H. De B. Parsons from the records of the U. S. Weather Bureau, and is appended to the document entitled "Basic Physical Data," December 1, 1911. The averages thus obtained are as follows:

Average Direction, Duration, and Velocity of Wind Near Battery During the Months June-September for the Years 1907-1911.

Direction of wind.	June. No. days.	Vel.	July. No. days.	Vel.	August. No. days.	Vel.	Sept. No. days.	Vel.	Total No. days.	4 Mos. Mean Vel.
N.	1.0	13.0	0.4	7.6	0.4	9.4	2.0	10.9	3.8	10.3
N. E.	4.6	12.4	2.6	8.4	5.2	11.6	5.2	10.7	17.6	10.8
E.	1.8	9.6	0.8	9.9	1.8	10.4	2.0	8.2	6.4	9.5
S. E.	2.8	9.4	2.6	7.8	2.4	9.0	2.4	10.5	10.2	9.2
S.	5.8	8.2	7.6	8.4	8.2	8.1	4.0	9.0	25.6	8.4
S. W.	3.4	8.8	6.6	10.0	4.4	10.1	5.2	9.1	19.6	9.5
W.	4.4	12.5	4.6	11.8	2.4	10.5	3.2	12.0	14.6	11.7
N. W.	6.2	12.1	5.8	13.8	6.2	12.3	6.0	11.7	24.2	12.5
Totals and averages.	30.0	10.6	31.0	10.2	31.0	10.2	30.0	10.4	122.0	10.3
Easterly	9.2	10.4	6.0	8.3	9.4	10.7	9.6	10.1	34.2	10.0
Westerly	14.0	11.4	17.0	11.8	13.0	11.2	14.4	10.8	58.4	11.3

These figures indicate that during the four warm months named the prevalent winds in the upper Bay come from the south and west, with an average velocity of about 10 miles per hour. While this average velocity is not great, yet it must be remembered that it is strong enough to cause drifts of the surface water, and that there are also many squalls during said period when the wind attains a very high velocity which will greatly affect surface currents and drifts of the water in the Bay.

Q. Mr. Kuichling, did you devote any of your studies to the rainfall, temperature and humidity?

A. I did. Tables showing the mean monthly and yearly precipitation, temperature and humidity in the vicinity of the Battery, have also been compiled by Mr. H. De B. Parsons from the records of the U. S. Weather Bureau, and are appended to the said "Basic Physical Data."

Q. After the line of studies that you have just described, and taking into consideration the location of Robbins Reef Light as the proposed point of discharge of the Passaic Valley sewage, and its quality and quantity, and the self purification of the harbor water,
1970 what results, in your opinion, would flow from the proposed discharge of the Passaic Valley sewage through the trunk sewer outfall at Robbins Reef?

Mr. Riker: To that I want to interpose an objection that the basis for any opinion evidence or expert evidence in this matter has not been laid by the formulation of a hypothetical question based upon evidence introduced in the case.

The Commissioner: Note the objection.

A. In the foregoing the probable volume of sewage produced in the Passaic Valley Sewerage District in the year 1940 has been considered, along with the physical characteristics of Upper New York Bay, into which it is proposed to be discharged near Robbins Reef Light after a relatively brief period of sedimentation in tanks at the pumping station; and it is now of interest to investigate somewhat more closely the probable nature of this sewage, and the results of its discharge at the point mentioned.

Location of Robbins Reef Light.—Robbins Reef Light is located in the Upper Bay at a point 0.54 mile westerly of the boundary line between the States of New York and New Jersey that passes through the northern half of said Bay, and 0.34 mile north of the same boundary line that passes through the Kill van Kull. It is also 1.25 miles east of Constable Hook; 0.92 mile northeast of St. George ferry dock at the northeastern corner of Staten Island, or Richmond Borough; 2.35 miles southeasterly from the main shore of the city of Bayonne, New Jersey; 2.00 miles northwesterly from the Brooklyn shore at Bay Ridge; 3.98 miles southwest from the Battery; 3.43 miles southwest from Castle William, Governors Island; 3.60 miles north of Fort Wadsworth, on the west side of The Narrows, and 6.18 miles northerly from Norton's Point or the west end of Coney Island. Robbins Reef Light is thus in the State of New Jersey and about half-way between Castle William and Fort Wadsworth, and near the mouth of the Kill van Kull.

Proposed Point of Discharge of Passaic Valley Sewage.

As nearly as can — determined from the plans of the Passaic
1971 Valley Sewerage Commission that I have seen, the middle point of the system of discharge pipes for the sewage is about 850 feet south and 1130 feet east of Robbins Reef Light. The system consists of two oblique main pipes, each about 300 feet long, and six lateral branch pipes, ranging in length from 80 to 160 feet, and covering a surface about 500 feet long, with an average width of 133 feet and having an area of 1.53 acres. These pipes are to be laid just below the surface of the mud bottom, and provided with 150 short vertical outlet nozzles, each having an area of 1.134 square feet for discharge, thus furnishing an aggregate area of 170.1 square feet. The two main pipes are each 8 feet in diameter, and provision is made on the drawings for a future third pipe, along with a similar set of three discharge pipes, whereby the area in which sewage is discharged will be increased about 50 per cent. This area is thus also in the State of New Jersey, but very near to the boundary line, and the water has here a depth of about 40 feet.

The volume of sewage to be discharged at maximum rate in the year 1940 is estimated by the Passaic Valley Sewerage Commission to be 553 cubic feet per second, or 357,365,200 gallons per day; but I regard this as being too low and believe that the figures should be raised to 1,295 cubic feet per second, or 837,000,000 gallons per day. Assuming that the aggregate area of discharge afforded by the 150 nozzles or outlets is 170.1 sq. ft., as aforesaid, then the mean velocity of discharge at maximum rate will be 3.25 feet per second according to the estimate of said Commission, and 7.61 feet per second according to my estimate. These velocities of discharge have a distinct effect on the rate at which the sewage will tend to diffuse in the salty water of the Bay, inasmuch as with a higher upward velocity the rise of the sewage to the surface will be accelerated.

Sewage has nearly the same specific gravity as distilled water, while that of sea-water is about 2.5 per cent. greater, so that the sewage tends to float on the surface of a body of salt-water. This tendency is clearly seen at all submerged outlets into sea-harbors, and is more apparent as the volume of sewage increases. The discolored liquid representing the sewage appears to rise quickly to the surface, and spreads out in a thin layer covering a large area, or so-called "sew-
age field," before the process of diffusion is completed. Ref-
1972 erence to this process was made previously, and many studies thereof have been undertaken, but there are so many attendant difficulties of observation in a busy harbor that the results exhibit much variation. A series of experiments with balls having the same specific gravity as fresh-water or sewage, was made by the Metropolitan Sewerage Commission in the Upper Bay, and an account thereof is given on page 457 of the report of that Commission dated April 30, 1910. From these data it was deduced by me that the mean velocity of ascent (v), in feet per second, of fresh-water

through salt-water of a salinity represented by the percentage (x) of fresh-water mixed with sea-water, is expressed by the relation:

$$v = \frac{0.7\ (100\text{-}x)}{133\text{-}x}.$$

During the four months July-October, the average salinity of the Upper Bay at Robbins Reef Light corresponds to 20.2 per cent. of land-water, according to the testimony of H. De. B. Parsons on February 27, 1912. With this value of (x) the above equation gives for the mean velocity of ascent: = .50 feet per second, thus making the time required for the sewage to rise through a depth of 40 ft. of water, about 80 seconds. From other observations at submerged sewer outlets, notably at Nut or Paddock's Island in Boston Harbor where an average discharge of 39,600,000 gallons per day, through two open-ended pipes each 5.0 feet in diameter and placed at a depth of 30 feet was maintained in 1910, the mean velocity of discharge being only $\frac{q}{a} = \frac{61.27}{38.27} = 1.60$ ft. per second, the sewage rises to the surface practically as a solid column with violent eddies at the top, where it spreads out over a wide area and travels with the tidal currents for an hour or more before the discoloration disappears. This example will suffice to demonstrate that little diffusion will take place during the 80 seconds needed for the sewage to rise through the said depth of 40 feet at Robbins Reef.

It is also highly probable that the size of the sewage "field" will increase in more than linear ratio to the rate of discharge, so that the great volume proposed to be discharged daily at Robbins Reef Light will doubtless extend over the entire distances traveled by the tidal currents. As previously stated, the flood current in the Upper Bay will carry a float about 8 miles northerly, while the ebb
1973 current will transport it about 10 miles southerly from Robbins Reef; hence it can be inferred that in conjunction with the eddying lateral currents and a strong wind, the entire surface of the Bay will frequently be polluted with this particular sewage, even if all the other tributary outlet sewers were permanently closed. It is likewise certain that in comparatively calm weather the lateral drifts already described will bring more or less polluted water and particles of sewage from the proposed outlet to the shores of Jersey City, Bayonne, Richmond (Staten Island) and Brooklyn. In sheltered coves such matter will accumulate and form offensive deposits.

Quality of Passaic Valley Sewage.—It was mentioned in the outset that the proposed trunk sewer would extend from the river falls in Paterson, New Jersey, to the salt meadows at Newark, New Jersey, where the sewage would be allowed to settle for one or two hours in suitable tanks. The length of this trunk sewer is stated in the Commissioner's report of 1908 to be 20.98 miles, and its size ranges from 4.0 to 13.5 feet in diameter; after settlement the liquid will be pumped through a 12-foot tunnel 5.07 miles long, and two 8-foot outlet pipes, each 0.20 mile long, to Robbins Reef. The total length from Paterson to Robbins Reef is thus about 26.25 miles and may

be divided into 3 sections, as follows: 1. The upper section from Paterson to a point 8.47 miles south, with diameters ranging from 4.0 to 7.5 feet and laid on a grade of 0.545 per 1000; 2. The middle section, 12.51 miles long, with diameters ranging from 8.0 to 13.5 feet, and laid on a grade of 0.38 per 1000, extending to the pumping station; 3. The lower or outlet section, 5.27 miles long, with diameters of 12.0 feet and 8.0 feet as described. It is now of interest to estimate the length of time required for the sewage to flow through these three sections, in dry weather in the year 1920.

It has already been stated that in 1910 the population of the Passaic Valley Sewerage District, as defined in the Commissioner's report of 1908, was 734,400, and that my estimate of the prospective population in the same territory in the year 1940 is 1,800,000 corersponding to an average decennial increase of 34.9 per cent. At this rate of increase the pop-
1974 ulation of the said district in 1920 will be 990,700; and if the dry-weather flow of sewage be estimated at 200 gallons per head per day, including ground water infiltration and industrial wastes, the daily volume of sewage will be 198,140,000 gallons, corresponding to an average flow of 306.6 cubic feet per second. This quantity will cause the trunk sewer to be filled to about one-half its diameter; and by computing the velocities in the several portions thereof by means of the Kutter formula, with a coefficient of surface roughness $n = 0.015$, it will be found that the time required for a particle of sewage to flow from Paterson to the proposed pumping station and settling tanks is 8.80 hours. It may also be remarked that the same length of time is required if the sewer were running full. As the sewage will probably be pumped continuously at its average rate of production throughout the day, the time taken for forcing the said quantity through the tunnel and outlet pipes will be 2.83 hours.

To these periods of time required for transit from Paterson to Robbins Reef, must be added the period allowed for sedimentation in the tanks at the pumping station, and the time of passage through the system of local sewers in Paterson and other outlying communities in that vicinity. The former may be taken as two hours, in accordance with the agreement made with the U. S. Government in 1911, so that the said transportation and storage period becomes about 13.6 hours; and in regard to the time required for flowing through the longest line of sewer in Paterson, etc. a period of about three hours may be taken, as it is probable that in 1920 the length of such line will be at least 3 miles, and that the average velocity therein will not be more than 1.33 miles per hour in dry weather. This velocity is equivalent to 1.96 feet per second, and numerous observations of the flow in the sewers of other cities have shown that swifter flows are exceptionel in time of drought.

It is thus seen that the sewage arriving at Robbins Reef from the most remote points in the territory will be about 16 hours old,
1975 which is much longer than necessary to render it highly septic and malodorous during the warm season, and is also sufficient to infect and induce active decomposition in the remaining

large volume of fresher sewage. A further opportunity for such infection is afforded by old deposits in both the local sewers and the long trunk sewer, as well as by the sojourn in the settling tanks; hence it is very probable that the liquid proposed to be discharged at Robbins Reef will have a strongly offensive odor at times.

In consequence of the tidal oscillation of the water in the Upper Bay, and the relatively small volume of resultant tidal outflow through the Narrows during a dry summer and autumn, this malodorous sewage will come in contact with water which was previously polluted, and is therefore unable to absorb a large additional quantity of offensive gases. The latter will accordingly escape into the air from the extensive floating stratum of sewage, and a nuisance will be developed at such times which will be carried by the winds to the adjacent shores. Of the effects of this atmospheric pollution little need here be said.

It may also be remarked that the offensiveness of the gases resulting from the putrefaction of sewage is often due to peculiarities of composition of the industrial wastes. Many such products emit extremely nauseating and penetrating odors, as for example the wastes from breweries, starch factories and certain oil refineries. Industries of this kind are already established in the Passaic Valley Sewerage District, and more will doubtless come in the future. The sewage of the District is therefore likely to contain an unusually large proportion of trade wastes that will cause the development of four odors.

Reference to the map and the data relating to the prevalent directions of the wind in the Upper Bay, will suffice to show that the pollution of the atmosphere in the warm season, from the oscillating fields of sewage due to the continual discharge of the proposed large volume at Robbins Reef Light, will certainly be perceived keenly along both shores from the Narrows to at least Governors
1976 Island; also that the odors may occasionally be carried much father north. It must also be remembered in this connection that the said volumes of sewage are unusually large, being far greater than is now discharged at any single outlet in the cities of New York and Boston, and becoming in 1940 nearly as great as was the average daily volume of sewage in Glasgow (250,000,000 U. S. gallons) and London (340,000,000 U. S. gallons) in the year 1909. The latter figures are taken from the official annual reports of the chief engineers of the two cities mentioned.

Self-purification of the Harbor Water.—The water in the Upper Bay is a mixture of land-water and sea-water, and varies in salinity within wide limits during the year. According to the testimony of Mr. H. De B. Parsons given on February 27th, 1912, the percentage of land-water at Robbins Reef ranges from a maximum of 56.1 in April to a minimum of 18.3 in September, the average for the year being 31.2. The self purification of polluted water is essentially a biological process, performed by a multitude of more or less minute plants and animals, most of which have been adapted by Nature to thrive only in waters which are either mainly fresh or mainly salt. While this subject is not yet fully understood by naturalists, it has

been found that for some reason the essentially fresh-water organisms do not survive long when transported by streams into the sea, and conversely, that the essentially salt-water organisms will not prosper in the slightly brackish water of the upper portion of tidal estuaries. Some of each class, however, manage to exist in mixtures of fresh and salt water, such as is found in the Upper Bay, and it is also probable that another group is specially adapted thereto.

These organisms include the bacteria, whose particular function is to render solid organic matter soluble in water. This dissolved matter is then absorbed by a more highly organized class of plants and some of the protozoa, and these two classes in turn serve as food for larger animals. They remain either in suspension in the water, or permanently upon and in the mud on the bottom; in the first
1977 case they constitute what is called the "plankton", and in the second case the "benthos", or the fixed and crawling life on the bottom.

A thorough study of fresh-water plankton and benthos has been made in recent years by Drs. Marsson and Kolkwitz, of the Prussian Experimental Station in Berlin; the plankton of various bodies of salt water has likewise been studied extensively; but comparatively little attention has hitherto been given to the plankton and benthos of brackish water, and therefore the processes of self-purification of water, like that of the Upper Bay, are still somewhat obscure. From such knowledge as is now available, however, it may be concluded that considerably more time is required for their completion than in either fresh-water or sea-water.

As previously mentioned, the process of self-purification depends to some extent on the amount of dissolved oxygen in the water, as this gas is necessary for the existence of most of the organisms involved; and it has been pointed out above that much of the dissolved oxygen is soon absorbed by the organic matter contained in the sewage. It has also been shown that the rate at which de-oxygenated water re-absorbs oxygen from the atmosphere is not well understood, although it is recognized that it proceeds quite slowly when the water is not violently agitated. Such violent agitation is largely precluded in the Upper Bay and its tributaries, owing to their moderate size and high shores; hence the conclusion must be that a rapid reoxygenation of the polluted water does not take place.

Conclusion.—In view of all the considerations set forth in the foregoing, it is my opinion that the operation of the Passaic Valley Trunk Sewer, as proposed by the Commission, will result in the creation of a nuisance in the vicinity of Robbins Reef Light, and that the same will be perceived in the warm season not only by people on vessels, but also by the people residing on the shores of the Upper Bay from the Narrows to Governor's Island, and probably also beyond these limits at times. Furthermore, this opinion would be
reached even if no other sewage than that of the said Passaic
1978 Valley District were emptied into the Bay.

The resulting injury to the public health, and the damage to the various public and private properties and interests affected by

the operation of said trunk sewer in the manner proposed have not been considered — the foregoing.

Adjourned to June 14th, 1912 at 10:30 A. M.

Supreme Court of the United States, October Term, 1911.

PEOPLE OF THE STATE OF NEW YORK, Complainants,
vs.
STATE OF NEW JERSEY and THE PASSAIC VALLEY SEWERAGE COMMISSION, Defendants.

CORPORATION COUNSEL'S OFFICE,
NEW YORK, June 14th, 1912 —10:30 a. m.

Present: James D. Maher, Esq., Commissioner.

Appearances:

Dr. William J. O'Sullivan, Special Counsel for the People of the State of New York, Complainants.
Adrian Riker, Esq., for the Passaic Valley Sewerage Commission, Defendants.

Met pursuant to adjournment.

EMIL KUICHLING a witness called on behalf of the Com-
1979 plainants, recalled for further examination, testified as follows:

Direct examination by Mr. O'Sullivan (resumed):

Q. Mr. Kuichling, have you made tours of inspection of the Passaic Valley region, which is to be served by the Passaic Valley trunk sewer projected, and, if so, state what your observations were relative to the sources and character of the proposed discharge into New York Bay through the Passaic Valley Trunk sewer?

A. I have made many tours of inspection through the Passaic Valley region since the autumn of 1889, and I lived at Paterson for several months as an Assistant Engineer on the preparation of plans for the water supply of the city of Newark, New Jersey. I was later employed as Consulting Engineer for the Water Supply of Jersey City, New Jersey. The pollution of the Passaic River which formerly was the source of water supply for these two cities, was thus brought to my notice, and I became interested in both the causes and effects of such pollution.

The Passaic River above Paterson received comparatively little sewage, as there are not many large towns in the water shed which are provided with sewerage systems, and the principal city contributing much sewage in the upper part of the Passaic Valley region is Paterson, with its numerous industries. Below Paterson there are many other towns which are provided with sewerage systems, and discharge crude sewage directly into the river. Most of those towns

have extensive industries, which produce liquid wastes that are also discharged into the river, directly or indirectly through the sewers. During 1889 and 1890 I made several close inspections of the Passaic River from Paterson to Newark, taking samples of the water and mud near the shores, for microscopical examination and observations of fermentation. These examinations convinced me that the water of the river was badly polluted during the dry season with organic matter of sewage character, and that the City of Newark was fully justified in seeking a new source of water supply.

Similarly also with Jersey City. The industrial wastes dis-
1980 charged into the river directly and indirectly through tributary sewer systems attracted my attention and interest greatly, not only by their diversified character, but also by their large quantity. Many times while living at Paterson did I see the river become colored for long distances by dye wastes from the great silk mills in Paterson and I have seen the skins of boys swimming in the river distinctly colored by such wastes. The water of the river appeared black in dry seasons, but a closer examination of the water showed that the black color was due more to the black mud on the bottom than to coloring matter in the water itself. In hot weather I have seen extensive developments of gas from the mud on the river bottom, showing in the form of small bubbles bursting at the surface of the water, and giving it the appearance of being agitated by drops of rain water.

My last inspection of the Passaic Valley region between Newark and Paterson was made on August 8 and 9th, 1911.

I saw numerous large sewer outlets discharging crude sewage into the river, and found offensive odors emanating from the river water in many places. The water was inky black in appearance and it was covered with a greasy scum in many localities. Especially near the sewer outlets, the water was very turbid and contained much floating matter with fragments of human excreta plainly visible. My notes of this inspection contained the statement that the condition of the river was then much worse than when I studied it first in the autumn of 1889, while living at Paterson. I particularly noticed extensive banks of muddy sludge in the river near sewer outlets, also much dye-water which stained the scum and the banks in various colors. I saw the color of sewage issuing from the sewers change gradually from gray to green, blue or red, and I noticed plainly the presence of stifling gases, such as ammonia and carbolic acid at the sewer outlets. A faint odor of sewage from the river was noticed at many places on the roads on each side of the river at a distance of a few hundred feet from the water, while at the edges of the river itself these sewage odors were more noticeable. During this inspection I saw many textile mills and chemical
works in full operation between Paterson and Newark, and
1981 was impressed with the extensive development of industries in this region as well as with the growth of population.

From all these studies and observations of the Passaic Valley region, I was convinced that the sewage to be intercepted by the proposed Passaic Valley Trunk Sewer would be not only unusually

large in volume per head of population, but also unusually strong in quality or amount of putrescible organic matter.

In my previous testimony I have already referred to the population and industrial wastes in this portion of the valley.

Q. Mr. Kuichling, have you made a special study of the quantity of liquid wastes produced in various industries, and if so, state what studies you have made and with what results?

Mr. Riker: My objection to that is that insofar as it is competent for the purpose of qualifying him as an expert, the question calls for an answer that would be immaterial and irrelevant in this suit.

The Commissioner: Note the objection.

Mr. Riker: I would like to have it appear on the record that the witness proposes to read the report which has already been prepared, and I desire to interpose an objection that it is not the proper method of testifying in a cause, and I also desire to observe the general objection, that insofar as this testimony deals with facts not under his own observation and consists of opinion evidence upon those facts, that it is incompetent, as not being based upon a hypothesis, taking into account the evidential matters introduced in evidence in this cause.

The Commissioner: Note the objection of counsel for the defendants.

A. The amount and the character of the liquid wastes produced in various industries have attracted my attention as a sanitary engineer for many years, and recently I compiled the results of my personal observations and the memoranda made from the study of the observations of others into the form of a general outline. The
1982 memoranda mentioned were made from reading many books, treaties, reports and papers relating to various industries, and the quantity of liquid wastes derived therefrom. Other memoranda were obtained from treaties on sewerage and sewage disposal.

Before stating the results of my studies, I consider it necessary to refer briefly to the liquid called sewage and its quantity.

In estimating the daily volume of sewage produced by a community, reference is usually made firstly, to the average daily water supply furnished by the public waterworks; secondly, to the quantity of water obtained from independent sources, especially by manufacturers; and thirdly, to the probable amount of ground water that finds its way into the sewers by infiltration. The first-named volume is generally known to the authorities in charge of the public water-works, but in regard to the second and third volumes little information is commonly available, and a knowledge of their magnitude must be acquired by long continued gaugings and comparisons of the discharge of the sewers at different hours of the day. This process, however is very tedious and difficult, and hence it becomes desirable to have at hand data relating to these two quantities of liquid that have been ascertained by actual measurement in other places.

In regard to industrial wastes, and approximate constancy of volume per unit of product is to be expected in the different indus-

tries, wherever they may be located, and it has accordingly been my purpose to submit the data that I have collected on this subject from numerous sources.

The industrial wastes of a city are usually considered collectively for the purposes of sewer construction; but when a purification of the sewage is undertaken, it becomes necessary to study also the character of these liquids in close detail, as their quantity will often determine the method of treatment to be adopted. The chemical composition of these wastes, is, however, so varied and complex that a detailed reference thereto is here omitted, and hence the data submitted refer essentially to quantity rather than to composition.

The volume of industrial wastes in a city is often surpris-
1983 ingly large, and in some cases it forms the greater part of the entire volume of sewage. Thus Büsing in his treaties on Sewerage (Städtereinigung," Stuttgart, 1897), states on page 148 that in Mülhausen, Alsace, with a population of about 90,000, and many large factories, the industrial wastes were four times larger in volume than the domestic sewage, so that if the latter were represented by 20 U. S. gallons per capita, the industrial wastes would amount to 80 gallons per capita daily. He also states that in Birmingham, England, with a population of nearly 500,000, the industrial wastes were 58 gallons per capita; in Glasgow, with a population of nearly 700,000, they were 96 gallons per capita; and in Rheims, France, with a population of 108,000, they were as much as 107 gallons per capita daily. It may be noted that in all these cities the public water supply was much less than the total trade wastes, the amounts being respectively 34, 67, and 52 U. S. gallons per capita daily.

Büsing also refers to the estimate of Schlösing and Durand-Claye that in cities having many large factories the industrial wastes would be from 53 to 79 U. S. gallons per capita, and he adds that in such communities it will be safe to assume that twice as much water will be used for industrial purposes as for domestic consumption. Presumably this remark is based on the usual European estimate of about 20 gallons per capita for purely domestic uses, so that the total volume of sewage in such cities, including trade wastes, will be about 60 gallons per capita daily, while according to Schlösing and Durand-Claye it will be from 75 to 100 gallons.

In his new treatise on Sewerage ("Entwässerung der Städte," Leipzig, 1910), Frühling likewise refers on p. 15 to the great variation in the proportion of factory wastes in the sewage of different cities, and states that while an allowance of from 7 to 11 U. S. gallons per head per day for industrial uses is often made in residential towns, yet in the manufacturing city of Dortmund, with a population of 143,000, the trade wastes actually were 53 U. S. gallons per capita daily. On p. 473 he also states that it is very unsafe to assume that the volume of sewage in dry weather is the same as that of the public water supply, as many industrial
1984 establishments commonly obtain much water from other sources and discharge their wastes into the sewers. The actual dry-weather flow in the sewers should therefore be carefully meas-

ured. Thus in Bremen, with a population of 214,000, the volume of sewage was found to be more than twice that of the water supply, and in Chemnitz, with a population of 255,000 it was more than three times that of the water supply.

The subject of dealing with industrial wastes was carefully studied in Germany several years ago, owing to the increasing pollution of the rivers by the discharges from many new manufacturing plants. Frühling makes its importance manifest by the statement (l. c. p. 414) that the liquid wastes of only the beet sugar and paper mills of Germany amount annually to nearly one-half the volume of purely domestic sewage that would ensue if the entire population of the Empire were provided with water and sewerage facilities. The statistics show that about fourteen million tons of beets per year are converted into sugar, and that the process involves the discharge of about 132,100 million U. S. gallons of impure water, or at the rate of 9440 gallons per ton of beets; also that about one million tons of paper and pasteboard are made in Germany per year, and that the process involves the discharge of about 26,420 gallons per ton. The total population of the German Empire in 1908 was about 60,600,000, and if an allowance of 15 gallons per head per day be made for domestic sewage, the resulting volume in a year would be about 331,800 million gallons, as compared with the 158,520 million gallons of liquid wastes per year from the two industries first mentioned.

In 1903, Messrs. Bredtschneider and Thumm, members of the Berlin Royal Testing Stations for Water Supply and Sewage Disposal, were sent by the Government to England to learn how the sewages of the various industrial cities of that country were treated. They made a valuable report entitled "The Purification of Sewage in England," which was published in Berlin in 1904; but as they had dealt mainly with town sewage, and more information was desired about the special treatment of factory wastes at isolated plants, Messrs. Schiele and Thumm made another tour
1985 through England in the latter part of 1905, and the results of their examinations and subsequent studies were published four years later in a comprehensive report by Dr. Schiele, entitled "The Treatment of Manufacturing Wastes and the Sewage of Industrial Cities." Berlin 1909. From this report many of the data submitted in the following have been taken.

As already mentioned, it is customary to consider the subject by giving the proportion of the industrial wastes to the total daily quantity of town sewage. There is, however, always much uncertainty about these figures, as it often happens that only a fraction of the manufacturing wastes of a city are discharged into the public sewers, so that their actual magnitude is generally not ascertainable from the reported volumes or proportions. I will therefore present subsequently the available data relating to the magnitude of the wastes from individual industries, as it may be necessary in some cases to admit their entire volume into the sewers.

The foregoing remarks are emphasized by the conditions existing in Bradford, England. Schiele states (l. c. p. 117-118) that

three miles in one portion of that city, having a resident population of not more than 2000, produce as large a volume of liquid wastes as would come from an ordinary town of 30,000 inhabitants. If the sewage of the latter be estimated at 40 gallons per head per day, it will follow that the wastes of the said three mills amount to 1,200,000 gallons per day. Furthermore, Bradford has a population of 300,000 and 170 factories that produce liquid wastes; its dry weather flow of sewage is 17,500,000 U. S. gallons per day, but this does not include 4,760,000 gallons per day of certain factory wastes which are discharged directly into the river after treatment on the premises. This latter discharge is due firstly to the requirement that the flow of the river must be maintained, and secondly that the crude wastes from these particular mills are not permitted to be emptied into the public sewers.

Another similar case is that of Paterson, N. J. The sewerage relations of that city were thoroughly studied by Messrs. Hazen & Whipple in 1905, and in their report published in 1906, it is estimated that the industrial wastes from the silk mills alone are
1986 more than 20,000,000 gallons per day, while the public water supply is only 8,400,000 gallons per day, or 75 gallons per capita for a population of 112,000. On page 69 of said report it is stated that most of the silk mill wastes are discharged directly into the river; also that some of these wastes are highly polluted and should be diverted into the sewers, but that the aggregate volume to be intercepted as sewage will not exceed 10 per cent. of the total volume of water used in the dye-houses, or 2,000,000 gallons per day. It may also be noted that about 1000 gallons of water are used per pound of raw silk, and that if all the manufacturing wastes of the city were considered, their volume would be at least eight times greater than the volume of purely domestic sewage.

Some similar data are given by G. B. Kershaw, C. E., in his new book on "Modern Methods of Sewage Purification" London, 1911, page 104. They have been incorporated in the following table along with a few others taken from American sources.

1987 *Table Showing Proportion of Industrial Wastes in the Sewage of 5 English and 10 American Cities; Also Relative Quantities in U. S. Gallons Per Head Per Day in Dry Weather.*

City.	Population.	Dry weather sewage. Gals. per day.	Per cent. of indust. Wastes in sewage.	Gals. per head per day.		
				Total.	Domest.	Industr.
English:						
Bradford	270,000	15,600,000	50	58	29	29
Burton on Trent	45,000	7,800,000	80	173	35	139
Leeds	450,000	20,400,000	33	45	30	15
Luton	38,500	2,040,000	33	53	35	18
Nottingham	260,000	9,000,000	43	35	20	15
Sum & Average	1,063,500	54,840,000	47	52	28	24
American:						
*Boston, Mass., 1892	430,200	41,312,000	31	96	66	30
Columbus, O., 1905	150,000	13,000,000	30	87	61	26
Gloversville, 1909	20,600	2,600,000	38	126	78	48
*Harrisburg, Pa., 1910	70,000	9,106,000	59	130	57	73
Milwaukee, Wis., 1911	373,900	61,690,000	35	165	108	57
*New York, N. Y., 1900	2,050,600	269,000,000	18	131	107	24
Passaic, N. J., 1905	38,000	10,500,000	67	277	92	185
†Paterson, N. J., 1906	112,000	11,200,000	25	100	75	25
*Rochester, N. Y., 1903	174,000	13,800,000	23	79	61	18
*Syracuse, N. Y., 1905	114,000	12,350,000	36	111	71	40
Sum & Av'ge	3,533,300	444,558,000	25	126	94	32
Sum & Av'ge (Exclus. New York)	1,482,700	175,558,000	35	118	76	42

NOTE.—*Denotes derived from Water Supply statistics.
†Denotes most of silk-mill wastes not included.

The authorities relating to the American data in Table III are as follows: Boston, Paper by D. Brackett, C. E., in Report of Massachusetts State Board of Health for 1895, pp. 166 and 174; Columbus, Report by Geo. A. Johnson, C. E., on sewage Purification of that City, 1905, p. 342; Gloversville, Report by Engineers H. P. Eddy and M. Vrooman on Sewage Disposal of that City, 1909, p. 28; Harrisburg, Report of Water Board for 1910, p. 82; Milwaukee, Report of Engineers J. W. Alvord, H. P. Eddy and G. C. Whipple on Sewage Disposal of that City, 1911; New York, (Manhattan and Bronx Boroughs), Report of J. R. Freeman, C. E., on Water Supply of City, 1900, p. 50; Passaic, Report of Metropolitan Sewerage Commission, 1910, p. 322; Paterson, Report of En-
1988 gineers A. Hazen and G. C. Whipple on Sewage Disposal of City, 1906, pp. 83 and 112; Rochester, Report of City Engineer E. A. Fisher for 1903, p. 147; Syracuse, Report of National Civic Federation, 1907, Vol. II, p. 231.

It must also be remembered that in most cases the figures given in the foregoing table do not represent the entire quantity of industrial wastes produced in the cities to which they relate, for the reasons already given; and it will therefore be prudent to consider them only as approximate estimates which should be increased rather than diminished.

In view of the uncertainties in the data, it becomes impossible to draw any trustworthy general conclusions about the proportion of industrial wastes that will find their way into the sewers of a comparatively small community. The average proportion in the entire list may be regarded as applicable to large cities; hence for such large communities it may be expected that the industrial wastes will constitute about one-third, or 33 per cent., of the dry-weather flow provided that the factories do not require unusual quantities of water, as in Paterson, Passaic and elsewhere. Estimated on the per capita basis, this average for the industrial wastes of large cities appears to range from 26 to 42 gallons per head of total population per day.

Very much larger figures, however, will be found if the city contains many industries that discharge large volumes of water into the public sewers. Thus in Buffalo, N. Y., several large manufacturing establishments consumed over 25,000,000 gallons of water per day in 1885, when the population was about 240,000, so that the daily per capita rate for these trades alone was 104 gallons. In Paterson, N. J., the per capita rate for the silk mills exclusively was about 200 gallons per day in 1905, while in Passaic, New Jersey, the rate for the woolen mills and other trades was 185 gallons. In Kansas City, Kansas, population 82,000, Wilmington, Delaware, population 87,500 and Erie, Pa., population 66,500, the daily per capita rates for manufacturing purposes alone were respectively 85, 46 and 59 gallons taken from the public water supplies of those cities in the year 1910; and it is likely that
1989 considerable additional quantities of water from independent sources were used by the factories.

Numerous other instances of large per capita rates for industrial

wastes might be cited, but the foregoing are sufficient to show the importance of acquiring more definite information about the magnitude of such wastes by actual measurement before designing sewage disposal works for large communities.

Quantities of Liquid Wastes From Various Industries.

The following list is by no means complete, but it embraces all the data that have been collected by me after much search. No attempt is here made to describe in detail the various processes to which the different raw materials are subjected in order to adapt them to use by mankind, but the purpose has been to indicate the total quantities of water required per unit of weight, or other convenient measure, of finished product. Most of this water becomes more or less polluted and must be removed promptly from the premises. If other suitable recipients for such wastes are not at hand, they must obviously be discharged into the public sewers, with or without preliminary treatment, according to circumstances.

It often happens that definite information as to the quantity of waste cannot be obtained directly from a manufacturer, or is very difficult to obtain by actual measurement. In such cases the data herewith submitted may be of some service in arriving at an estimate of the total quantity of industrial wastes which are likely to reach the sewers of a community when the output of finished product is known or ascertainable.

Abattoirs.—According to König, "Städekanalisationen," Leipzig, 1902, p. 14, the quantity of water used in public slaughter houses in European cities ranges per head from 26 U. S. gallons for small animals to 79 gallons for cattle. In Glasgow, Scotland, three such establishments used in 1884 an aggregate of 11,300 U. S. gallons per day on the average. (Engrg. Record, N. Y., Vol. 12, 1885, p. 148).

Bleaching and Dyeing.—See Cotton and Woolen Mills.—A dyeworks in Glasgow, Scotland, was reported by Dr. Wm. Wallace in 1884 as using 240,00- U. S. gallons per day on the average. 1980 (Engrg. Record, Vol. 12, 1885, page 148).

Breweries and Distilleries.—Much conflicting testimony is found in regard to the quantity of liquid wastes from breweries and distilleries. From data obtained in Rochester, New York, in 1890, it was found that some of the large breweries were using water at the rate of more than 50 gallons per gallon of beer made. In 1882, the water supply to one of the large breweries in Milwaukee, Wis., was metered and the consumption was found to be about 16 gallons per gallon of beer brewed.

In the Report on the Sewage Disposal of Paterson, N. J., made in 1906 by Messrs. Hazen & Whipple, it is stated that the quantity of water used for malting, washing and refrigerating in the Hinchliffe brewery in Paterson was about 20 gallons per gallon of beer or ale, and that on this basis the amount of brewery wastes in that city would be 450,000 gallons per day or 4 gallons per capita,

and would contribute daily 150 lbs. dry weight of very objectionable organic matter to the domestic sewage.

English estimates made by Dr. H. McL. Wilson of the West Riding (Yorkshire) Rivers Board, range from 1.5 to 7 gallons per gallon of beer, not including the water used for cooling. Later estimates cited by Schiele in 1909 range from 5 to 6 gallons per gallon of beer or ale, excluding water used for cooling, and the same figures are also used by French authorities. Naylor, in his book on "Trades Waste", London, 1902, page 145, states that in three large English breweries the liquid wastes were respectively 86, 91 and 109 gallons per gallon of brew, thus giving an average of 95.5 to 1. He also states that distilleries usually discharge from 15,000 to 25,000 gallons of waste liquids per day; but in a paper on the "Bacterial Treatment of Trades Waste" before the Institution of Civil Engineers, Vol. 148 (1902) pp. 170-261, he stated that an average brewery and distillery produce each about 30,000 gallons of wastes per day.

Somewhat higher figures are found in Schiele's book on "Sewage Disposal of Industrial Cities", Berlin, 1909, as he gives therein the following average daily discharges of brewery wastes into sewers:—page 135, nine breweries in Blackburn, 1,220,000 U. S. gallons; page 287, three at Guilford, 213,700 gallons; page 299, three at Lichfield, 198,200 gallons; page 307, one at Rothwell, 92,500 gallons; total for 16 breweries, 1,724,400 gallons per day; whence the average per brewery is 107,775 U. S. gallons per day.

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The distillery wastes of four establishments in Glasgow Scotland, were estimated at 327,700 gallons per day on the average by Dr. Wm. Wallace in a report made to the City Council in 1885, (Eng'r'g Record, Vol. 12, 1885, p. 148). In Water Supply and Irrigation Paper No. 179, U. S. Geol. Survey, Washington, D. C., 1906, entitled "Pollution of Streams by Distillery Refuse," Mr. H. Stabler states on page 34 that one bushel of grain mashed produces 45 gallons of waste slop liquor.

Both brewery and distillery wastes are very putrescible and ferment easily, so that they tend to increase the offensive odor of sewage.

Chemical Works.—A great variation in the daily quantity of waste liquids is found in chemical works, depending on the nature of the business carried on. Three such establishments in Glasgow discharged in 1884 about 25,000 gallons per day into the sewers. In some cases the character of the wastes is such as to interfere so seriously with processes of sewage purification that their discharge into the public sewers is forbidden.

Coal Washing.—Much diversity in the practice of washing coal seems to prevail. The British Rivers Pollution Commission of 1874 found that from 660 to 1,320 gallons of water was then being used to wash a ton of coal, but subsequently the quantity was greatly reduced by the demand for proper treatment of the waste water so that a large portion of it could be used over again. Schiele states (l. c., p. 506) that the resultant waste is now about 320 gallons

per ton, while Naylor (l. c., p. 252) states that the final effluent to be purified ranges from 120 to 180 gallons per ton. This waste liquid is very dirty and contains a large quantity of solids both in solution and suspension.

Cotton Mills.—The principal wastes from cotton mills result from washing, bleaching and dyeing operations. In the Report of the Massachusetts State Board of Health for 1900, page 394, Mr. H. W. Clark states that the wastes from a mill producing
1991 40,000 yards per day of khaki and duck cloth were 140,000 gallons per day of ten hours, or at the rate of 3.5 gallons per yard. These wastes were very turbid and contained much flocculent matter. The analysis showed that the total solids amounted to 3,380 parts per million, of which 1,427 parts were lost on ignition. Lime, soap, acids and dyes were used in the various processes. This plant was enlarged in 1909 and then yielded 500,000 gallons of waste per day of ten hours.

On page 397 of said Report, Mr. Clark refers to a mill where cotton yarn was bleached, dyed and mercerized, producing from 60,000 to 70,000 gallons of very dirty wastes per day. The total solids in this liquor were 4,532 parts per million, of which 1,017 parts were lost on ignition. On page 390 he also refers to a mill for making cotton gauze and batting, from which the wastes were from 50,000 to 60,000 gallons per day, containing total solids to the extent of 2,926 parts per million, with 696 parts loss on ignition. Ammonium hydrate, bleach, soap, acids and dyes were used in the processes.

Schiele refers in his aforesaid book, pages 343-365, to the wastes from five large English cotton mills at Bury Cheadle, Church, Church-Foxhill and Leyland. The aggregate number of operatives is 3,630 and the aggregate quantity of liquid wastes is 3,847,000 U. S. gallons per day, or at the average rate of 769,400 gallons per day from each mill. In the case of Leyland with a population of 7,000, nearly the whole of the sewage comes from the cotton mill.

In a paper on the "Treatment of Trades Waste" by Wm. Naylor before the Institution of Civil Engineers in 1898, Vol. 123, pp. 388-405, reference is made to a calico printing and bleaching mill having wastes of 117,400 U. S. gallons per day. In a paper on the same subject by R. A. Tatton and W. O. E. Meade-King before the same body in 1900, Vol. 140, pp. 2-71, mention is made of a larger mill of the same kind at Chadkirk with wastes of 1,200,000 U. S. gallons per day. The cotton bleaching, dyeing and finishing mill of Clay & Sons at Cheadle are also credited with 360,000 to 600,000 U. S. gallons of wastes per day, and four other mills for printing, dyeing and bleaching cotton cloth are credited with an aggre-
1992 gate of 840,000 U. S. gallons of wastes per day, ranging from 72,000 to 360,000 gallons per day. The aggregate number of operatives in these four mills is 786.

Naylor states in his book on "Trades Waste", p. 183 that the waste liquors from calico printing are highly charged with objectionable gums or thickenings, which form the medium for placing the colors on the rollers. These thickenings may be albu-

men, casein, china clay, pipe clay, dextrin, glue, gluten, glycerine, gum senegal, gum tragacanth, molasses, lead sulphate, potato starch, salep, shellac, sugar, wheat flour, wheat starch, zinc chloride, zinc nitrate, etc. These substances are washed out by soap solutions after printing, and the resulting liquors are very polluting and difficult to purify. He also states on page 174 of said book that in bleaching cotton cloth, the wastes are produced at the rate of about 6,000 U. S. gallons per ton (2,240 lbs.) of dry cloth per day. The dissolved solids in these wastes consist of ammonia, silica, sodium chloride, calcium chloride, and sulphates of ammonia, lime and iron, while the suspended solids are starch, lime, etc. The former amount to about 1,300 parts per million and the latter to 360 parts, according to one analysis.

Creameries or Dairies.—Some of the wastes from creameries and dairies contain much putrescible matter. According to analyses reported by H. W. Clark in the Report of the Massachusetts State Board of Health for 1909, page 383, the strongest wastes contained 1,450 parts per million of total solids, of which 1,307 parts were lost on ignition. The rate of production of waste is not given.

Dye Works.—See Bleaching, also Cotton and Woolen Mills.

Gas Works.—The wastes from illuminating gas works are very turbid and dark-colored, and contain much oily matter. They are saturated with hydrocarbons in solution and have a heavy sediment of tar. Chemical treatment is required for coagulating and precipitating a large percentage of the suspended and dissolved matters. The mode of treatment varies if the gas is made from coal or oil. The amount of solids in the wastes ranges from 30,000 to 520,000 parts per million, most of it being lost on ignition. The volume of wastes from water-gas plants varied from 5,000 to 25,000 gallons of liquid per day, while that from coal-gas plants was much less. (H. W. Clarke in Report of Massachusetts State Board of Health for 1908, page 393-4.)

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In Hazen & Whipple's Report on the "Sewage Disposal of Paterson, N. J.," 1906, appendix IV. P. 84, Mr. H. W. Clark states that the gas plant of that city produces water gas from 10,000 to 12,000 gallons of Texas oil per day, and that the present average consumption of gas is 2,500,000 cubic feet per day. The amount of waste liquor passing from the works into the river is from 30,000 to 40,000 gallons per day. This is at the rate of 12,000 to 16,000 gallons of waste liquor per million cubic feet of gas. From 1500 to 2000 gallons of tar per day are extracted from the wastes before discharge.

Glue Works.—A plant employing 115 operatives for making glue from the skins, heads and bones of fish, produces 120,000 gallons of putrescent and malodorous liquid wastes per day. (H. W. Clark in Report of Massachusetts State Board of Health for 1909, page 400.)

Laundries.—The volume of wastes from laundries seems to vary greatly, depending on the work done. Estimates range from 1 to 3 gallons per pound of fabric washed. The lowest estimate found is 0.6 gallon per pound, given by König, l. c., p. 14.

Leather Dressing Works.—The operations in this industry relate to the treatment of hides after they have been tanned, and are often performed in tanneries. No definite figures for the wastes were found, but from a few vague estimates the rate seems to range from 5 to 20 gallons per pound of leather.

According to a report made in July 1902 by Dr. H. McL. Wilson to the West Riding Rivers Board, England, a plant which dresses 90 skins per day discharges 2160 U. S. gallons of waste liquid daily.

Paint Mills.—Complaints are sometimes made of the wastes from mills where mineral paints are made. Varios substances are used,
such as chrome iron ore, lime, sodium bichromate, sodium
1994 carbonate, lead acetate, sulphuric acid etc., and the wastes contain much solid matter. In a case cited by H. W. Clark in the Report of the Massachusetts State Board of Health for 1909, page 402, such a mill discharged from 25,000 to 28,000 gallons of waste liquor per day.

Paper Mills.—Much variation in the quantity of waste liquid per ton of paper is found in different places. The testimony given before the British Rivers Pollution Commission of 1865 indicates that about 150,600 U. S. gallons were produced in making a ton (2240 lbs.) of paper from old paper and rags, and it seems from the data obtained by Schiele in 1905 that the quantity has not been greatly reduced in modern English practice of making the best paper. Thus he states (l. c., p. 376) that in the Turkey Mills near Keighley, Yorkshire, which use only new linen and linen rags, the wastes are about 145,300 U. S. gallons per long ton of paper, while at the Dean Mills at Luddenden, which use rags, old paper and wood pulp, they are 158,500 U. S. gallons per long ton. It is stated, however that about one-third of this quantity is comparatively clean rinsing water.

In France similar large volumes of liquid wastes occur in paper mills. In a treatise on "Industrial Wastes" by P. Razous, Paris, 1905, page 263, it is stated that the process of making paper involves about 171,000 U. S. gallons per long ton of finished product, and that the supply of water required is 3.33 per cent. more in order to compensate for the loss by evaporation, etc.

In Germany, according to Schiele (l. c., p. 488), the quantity of liquid wastes is much smaller, being only about 53.000 U. S. gallons per long ton, but it is probable that this is due to the moral general use of wood pulp or cellulose, which seems to require less water than rags and old paper.

According to Frühling's estimate previously cited, the average is only 26,420 gallons per long ton, but it is possible that this relates to the more impure wastes.

1995 English paper mills using wood pulp and sulphite are likewise producing less wastes than those which use rags and old paper. Thus Schiele (l. c., p. 381) credits the Darwen Mills with from 15,100 to 37,300 U. S. gallons per long ton, according to quality of product. He also credits the mill of Olive & Parting-

ton at Glossup, which uses mostly Norwegian sulphite pulp, with 47 600 U. S. gallons per long ton.

In the United States, H. W. Clark states in the Report of the Massachusetts State Board of Health for 1909, page 370, that in two large paper mills in that State the wastes produced were as follows: From the first mill, which used mostly old paper, old rope, jute, etc., and produced 20 tons of paper per day, the wastes were about 1,850,000 gallons per day, or at the rate of 92,500 gallons per ton. From the second mill, which used wood pulp and from 5 to 15 per cent. of rags, and produced 25 tons of white magazine paper per day, the wastes were at the rate of about 20,000 gallons per ton for the more polluted portion of the total quantity.

To the 5100 tons of stock material used in the first mill during the year there was added about 1000 tons of china clay, starch, dyes and chemicals consisting of alum, bleach, caustic soda, copperas, lead bichromate, lime, soda ash, etc. Similar substances were also added to the stock in the second mill. The liquid wastes of both mills were analyzed, and each was found to contain about 430 parts per million of total solids, of which 200 parts were lost on ignition. It also stated that 40 per cent. of the materials used are lost in the wastes.

Other available data refer only to the average volume of daily wastes of paper mills as follows: The two mills in Massachusetts just mentioned each discharged from 2,000,000 to 3,000,000 gallons per day; the Glossup Mill, England, 1,347,400 gallons per day; the Darwen Mills, England, 1,057,000 and 613,400 gallons per day; the Ryburn and Bury Mills, England, 396,300 and 465,000 gallons per day respectively; the Turkey Mills, England, 290,600 gallons per day; Crehore & Son's Mill at Newton Lower Falls, Mass., (Rafter & Baker, Sewage Disposal, New York, 1894, page 301), 400,000 gallons per day; 2 mills in Reading, Pa.
1996 (Eng'r'g News, N. Y. 1907, II. p. 197) 1,080,000 gallons per day.

Pasteboard and Strawboard Mills.—The product called "binder's board" is made mostly of old paper and clay. H. W. Clark states in the Report of the Massachusetts State Board of Health for 1909, page 386, that he had examined the wastes of such a mill and found them very foul. The volume was from 250,000 to 300,000 gallons per day.

An estimate of the rate of waste from the manufacture of "newsboard" or "paperboard" was kindly furnished to me recently by Mr. P. C. Brashear, of the Fort Orange Paper Co., Castleton, N. Y., the same being 1,000,000 gallons per machine making from 25 to 50 tons of "board" per day, depending on the thickness. If the average daily output of a machine be assumed at 40 tons, the waste liquid will accordingly be produced at the rate of 25,000 gallons per ton.

Strawboard is made mostly of straw and is a coarse thick fabric. The wastes from such mills are fully described by E. B. Phelps in Water Supply and Irrigation Paper No. 189, entitled "Pollu-

tion of Streams by Strawboard Waste," U. S. Geol. Survey, Washington, D. C., 1906; and on p. 1 it is stated that on the average 65,000 gallons of waste liquor containing 1173 lbs. of straw and *and* 490 lbs. of lime are produced per ton of finished board. There are 59 such mills in the country with an average output of about 10 tons per day, but some of them produce 30 tons per day and discharge 1,900,000 gallons of waste daily. (P. 15).

Pulp and Sulphite Mills.—In Water Supply and Irrigation Paper No. 121, entitled "Pollution of Lake Champlain," U. S. Geol. Survey, Washington, D. C., 1905, pp. 25-27, M. O. Leighton states that in making soda pulp from poplar wood, about 51,900 gallons of waste liquor per ton of product are discharged. Thus the mill of the New York & Pennsylvania Co., at Willsboro, N. Y., has an effluent of about 800,000 gallons per day from a large sedimentation bed into which the various wastes are thrown to deposit their suspended matters. An analysis of this final effluent shows total solids 4230 parts per million, with calcium and magnesium 40.7 parts, sodium 803.4 parts, chlorine 143.9 parts, and nitrog-
1997 enous substances 0.43 part, so that the amount of organic matter is very small. It has a characteristic odor which permeates the water of the river and imparts a disagreeable taste to the fish.

The manufacture of sulphite pulp from spruce and hemlock wood is well described by E. B. Phelps in Water Supply and Irrigation Paper No. 226, entitled "The Pollution of Streams by Sulphite Pulp Waste," U. S. Geol. Survey, Washington, D. C., 1909. A cord of spruce wood weighs about 3600 lbs. of which 2000 lbs. is actual wood substance, the remainder being water. Of this dry wood substance only one-half (1000 lbs.) is found in the dry pulp. The volumes of waste liquor per ton of finished product is not definitely stated, but it can be inferred that it is from 5000 to 6000 gallons, as a digester charge of 16,000 gallons of acid liquor produces 7 tons of air-dry pulp, and is subsequently diluted with one or two times its volume of water in the blow pit, along with other wastes (p. 20). The charge also contains about 132 lbs. of lime and 343 lbs. of sulphur, of which about two-thirds appears in the effluent. Ten per cent. by weight of the effluent is solid matter, mostly organic.

The sulphite process is also described by H. G. Kittredge in U. S. Census Bulletin No. 190, Washington, D. C., 1902. He states that it is accompanied with waste liquor amounting to 10 or 12 times the weight of the pulp, and that this liquor has from 9 to 10 per cent. of dry solid residue, of which about 80 per cent. is organic matter. The dry residue in the wastes has therefore about the same weight as the pulp produced. Assuming that a ton (2000 lbs.) of the wast- liquor is equivalent to a volume of 234 gallons, the quantity of liquid waste per ton of pulp would accordingly be from 2300 to 2800 gallons.

Another description of the sulphite and soda processes is given in the "Report on the Pollution of Lake Champlain and the Bouquet and Au Sable Rivers by Wood Pulp Mill Refuse," made in December,

1904, to the State Health Commissioner of New York by O. H. Landreth, and printed in "Engineering News" of
1998 May 25, 1905, Vol. 53, p. 541. The daily volumes of liquid wastes are not given, but it is stated that in the sulphite Pulp and Paper Mills of the J. & J. Rogers Co. at Au Sable Forks, N. Y., about 100 cords of wood are used per day, and that the dry weight of the matter in the liquid wastes amounts to 171,000 lbs. per day, of which 150,000 lbs. is wood substance 15,000 lbs. is lime, and 6000 lbs. is sulphur.

In the soda-pulp mill of the New York and Pennsylvania Co. at Willsboro, N. Y., about 1000 cords of poplar, bass, beech and white birch wood are used per month, or about 38 cords per day, along with 15,000 lbs. lime, 5,000 lbs. bleach or calcium hypochlorite, and from 2,500 to 3,000 lbs. fresh soda-ash per day, a portion of the original amount of soda being recovered and used over again. The total quantity of refuse in the form of sedimented sludge is 44,000 lbs. or 622 cu. ft. per day, not considering the dry wastes of chips and small fragments from the wood, the cinders, etc.

Silk Mills.—The liquid wastes from silk mills are great in magnitude and contain many substances. H. W. Clark states in the Report of the Massachusetts State Board of Health for 1909, page 392, that one such mill discharged about 2,500,000 gallons of waste liquor per day, and that about 50 different substances were used in the operations; also that in spite of the large number and variety of chemicals allowed to run to waste, the liquor was never sterile, but generally contained at least 3,000,000 bacteria per cubic centimeter. Unfortunately, the number of pounds of silk used by the mill per day is not given.

In a paper by Mr. Clark in "Journal of the New England Water Works Association," December 1901, Vol. 15, pp. 508-9, reference is made to a silk mill in New England which had liquid wastes amounting to 2,500,000 gallons per day, and obtaining on the average 2000 lbs. soap, 1520 lbs. silk gum, 1307 lbs. dextrine, 339 lbs. nitrate of iron, 237 lbs. bichloride of tin, 235 lbs. sodium Phosphate, 173 lbs. sulphuric acid, 181 lbs. acetic acid, 115 lbs. hydrochloric acid, and an aggregate of 984 lbs. of various other substances, the
1999 total being 7091 lbs. per day.

The best available estimate of the quantity of water required for treating one pound of silk is given in the report of Hazen & Whipple on the Disposal of the Sewage of Paterson, N. Y., 1906, Appendix I, p. 9-20. It is there stated that in this city 7,600,000 lbs. of silk were dyed and 3,000,000 lbs. were manufactured annually, and that from 300 to 1000 gallons of washwater were required for each pound of silk dyed, the variation being due to the character of the dyeing. Analyses of the waste waters showed that they contained 2.05 lbs. of total solid matter per pound of silk, so that the 7,600,000 lbs. of silk dyed would correspond to 13,500,000 lbs. per year of solid matter in the wastes from the dye works. The amount of soap alone in the wastes is 13,300 lbs. per day, and the total amount of organic matter is 22,000 lbs. per day. It may be inferred from the

data that considering all the processes involved, the waste liquids are discharged at the rate of about 1000 gallons per pound of silk.

The quality of these waste liquids varies with the process to which the silk is subjected. Much of the water is used merely for rinsing the material after dyeing, and contains little putrescible matter. Mr. Whipple states that "the greater part" of the silk mill wastes may safely be discharged into the river, but that the remainder should go into the sewers.

Slaughter Houses.—See Abattoirs.

Starch Works.—The rate of waste in starch factories varies with the nature of the raw material used. F. Fischer states in his book entitled "Das Wasser," 3rd Ed., Berlin, 1902, p. 311, that starch factories using potatoes require about 159 U. S. gallons per bushel of potatoes. If Indian corn is used, the quantity of water per bushel of corn is much larger, but the figures are not now available. In 1885 an establishment of this kind in Buffalo, New York, discharged liquid wastes amounting to more than 2,000,000 gallons per day.

Sugar (Beet) Factories.—According to data given by F. Fischer, (l. c.) pp. 326-370, the quantity of liquid wastes per pound of raw sugar beets varies considerably with the process adopted, being from 1.1 to 2.7 U. S. gallons, and perhaps more. In the case of three mills for which the quantity of waste is explicitly stated, the range is from 2.0 to 2.7 gallons, and the average is 2.37 gallons per pound of raw beets.

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In regard to the character of these wastes, it is stated on page 327, that the quantity coming from a factory using 220.5 tons of beets per day, contains as much organic matter as the domestic sewage of a city of 50,000 inhabitants.

It will also be noticed that the above average rate of 2.37 gallons per pound, or 4740 gallons per ton, is only one-half the rate of 9440 gallons per ton given by Frühling on a former page hereof. A French estimate given by Debauve & Imbeaux in their large treatise on Water Supply "Distributions d'Eau," Vol. 2, p. 8, Paris, 1906, is 12 U. S. gallons per pound of sugar crystallized.

Tanneries.—H. W. Clark states in the Report of the Massachusetts State Board of Health for 1909, p. 341-349, that in a certain tannery dealing with sheep skins, the wastes are from 20,000 to 50,000 gallons per day. The liquid is thick and offensive, and varies in color with the aniline dyes used; it contains a very large amount of organic matter, which is in an advanced stage of putrefaction and it rarely contains any substance that will check bacterial action. Imported skins come packed in napthalene and arsenic, which are germicides, and arsenic sulphide is sometimes used to free the skins of hair.

Another tannery having 300 employees also did much wool scouring and prepared glue-stock. After being scoured, the wool was washed and rinsed in machines that used about 500,000 gallons of water per day. The most objectionable waste was from the glue-stock washer, amounting to 22,000 gallons per day.

F. H. Snow, C. E., in a paper on "Manufacturing Wastes" in

Engineering News of May 25, 1899, Vol. 41, p. 334, states that tanneries may discharge from 20,000 to 300,000 gallons per day.

2001 O. H. Landreth, C. E., in the Report of the N. Y. State Board of Health for 1899, pp. 74-76, states that the tanneries and leather dressing plants in Johnstown and Gloversville, N. Y., use water at the average rate of 9.8 gallons per pound of hide, or 21.1 gallons per pound of finished leather. The liquid wastes are very foul, as they contain 1.0 lb. waste animal matter and chemicals to 10.95 gallons of water. The figures indicate that the weight of the finished leather is only 46.4 per cent. of the weight of the raw hides, and that 53.6 per cent. of the weight of the hides is contained in the liquid wastes.

Messrs. H. P. Eddy and M. Vrooman, in their Report on the Sewage Disposal of Gloversville, N. Y., 1909, pp. 28-31, state that the gross weight of wet and dry hides tanned in that city annually is about 9,000,000 lbs. and that the liquid wastes from 26 tanning and leather mills is approximately 910,000 gallons per day. Assuming 310 working days per year, the average weight of raw hides treated per day would be 29,000 lbs., thus making the rate of liquid waste 31.4 gallons per pound of raw hide. They also state that the weight of the finished leather produced is about one-half that of the raw hides, so that the liquid waste is at the rate of 63 gallons per pound of finished leather. It will be noticed that this rate is three times greater than that indicated in the preceding paragraph, and is possibly due to the use of different methods in recent years.

Dr. H. McL. Wilson gives some data for English tanning practice in a report made by him on July 14, 1902, to the West Riding (Yorkshire) Rivers Board. The figures are as follows: A tannery with a capacity of 1000 hides per week (or 167 hides per day) discharges 36,000 U. S. gallons daily; and a smaller tannery with a capacity of only 60 hides per week (or 10 hides per day) discharges 3600 U. S. gallons daily. The rate per hide is thus 216 gallons in the larger plant and 360 gallons in the smaller one. He also refers to a large tannery with a daily discharge of 60,000 U. S. gallons.

2002 Wm. Naylor gives a number of analyses of tannery wastes in his book on "Trades Waste," London, 1902, p. 126. These were taken from the "Proceedings of the Ribble Committee," and the average of four nearly similar sets of figures expressed in parts per million is as follows:

Dissolved Solids;	Totals 3120;	Mineral 1710;	Volatile 1410;
Suspended "	" 1100;	" 480;	" 630;

Albuminoid Ammonia 3.86; oxygen absorbed in 4 hours 29.0 parts.

He adds that even after very complete settlement these liquors contain much objectionable matter in solution which cannot be precipitated practically, and that on stagnating they are liable to putrefy and give off very offensive odor.

Woolen Mills.—The data in regard to the volume of liquid wastes from woolen mills exhibit much variation, doubtless because they

refer to different stages of the process of making cloth, and also because in some places the supply of water is limited or purification of the wastes is required. Rafter & Baker, in their book entitled "Sewage Disposal in the United States," 2nd Ed., New York, 1894, refer on page 296 to the Wanskuck Mills in Providence R. I., making woolen and worsted goods, and discharging 400,000 gallons of wastes per day in 1881; and state that this volume of liquid contained 2000 lbs. of alkali, acid, grease, fuller's earth and dye-stuffs.

On page 297, they state that in the Lorraine Mills in Saylesville, R. I., the waste liquid from wool washing was at the rate of 1 gallon of water to 1.5 lbs. of raw wool, and that the resulting weight of clean wool was 0.75 lb., thus making the rate 1.33 gallons per pound of washed, clean wool. This rate is said to be very much lower than is commonly found. They also refer to the 50 per cent. loss in weight between the raw and the cleaned wool, and state that the same loss occurred in the woolen mill of R. Bleakie & Co., Hyde Park, Mass.

On page 51, they cite the figures given by the British Rivers Pollution Commission, that in the process of dyeing wool 6 gallons of spent dye liquor was wasted per pound of raw wool. From this it can be inferred that if the same percentage of loss of wool occurred as given in the preceding paragraph, the rate would become 12 gallons per pound of cleaned and dyed wool.

2003 In a paper on the "Purification of Water after its Use in Manufactories," by R. A. Tatton and W. O. E. Meade-King in "Proceedings of the Institution of Civil Engineers" London, 1900, Vol. 140, pp. 2-71, the authors state that the liquid wastes from the Woolen Manufacturing and Dyeing Works of Kelsall & Kemp, at Norden near Rochdale, amounted to 216,000 U. S. gallons per day; also that those from a small woolen mill employing 92 operatives were 90,000 U. S. gallons per day.

In another paper before the Institution of Civil Engineers, London, 1896, Vol. 123, pp. 388-405, Wm. Naylor states that the waste liquor from Fox's Woolen Mill in Wellington amounted to 72000 U. S. gallons per day; and in his book on "Trades Waste," London, 1902, p. 103, he quotes from a report made in 1896 by Borough Engineer, J. H. Cox, of Bradford, England, to the City Council, in which the dry-weather flow of sewage from the city is given as 12,000,000 U. S. gallons per day; about one half of this volume is trade wastes, and includes 1,500,000 gallons of wool-washing suds and 2,400,000 gallons of spent dye liquor; furthermore, over 3,600,000 gallons per day of mill wastes, consisting mainly of spent dye water, go directly into the Bradford Becks.

Concerning the character of the wool-washing wastes, Naylor states on p. 103-104 (l. c.) that their treatment is extremely difficult owing to the very large amount of solid matter in suspension which contains much wool-fat. This fat has the remarkable property of adhering to water or forming an emulsion therewith which takes long to settle; it does not rise to the surface of the liquid like ordinary fats, but remains in suspension in the form of minute globules, and is very difficult to separate mechanically; it forms

about 20 per cent. of the total solid matter extracted from the crude wool by the washing operations. If these suds are mixed with domestic sewage, they will seriously retard sedimentation and chemical precipitation, and will cause such precipitate to be very light or flocculent. This thin sludge contains over 98 per cent. water, while that from ordinary sewage contains only about 90 per cent. water; the extra 8 per cent. water signifies that the volume of the thin sludge is five times greater than that from ordinary sewage;
2004 it is also very difficult to condense by filter-pressing, and with the best appliances the resulting mass will contain 75 per cent. water, while that derived from ordinary sewage sludge contains only 50 per cent.

On pp. 75 and 105 (l. c.) Naylor gives the results of chemical analyses of raw wool and various effluents from the large woolen mill of Tankard, Scaife & Co. in Bradford, as follows:—Raw wool contains from 8 to 34 per cent. wool fat, 21 to 43 per cent. pure wool fibre, 3 to 24 per cent. dirt, and 12 to 23 per cent. moisture; another sample of raw wool gave 21.9 per cent. wool fat, 40.6 per cent. pure wool fibre, 20.0 per cent. dirt and 17.5 per cent. moisture. In comparison therewith the analysis of finished woolen cloth gave 5.2 per cent. wool fat, 81.5 per cent. pure wool fibre, and 13.3 per cent. moisture or water.

The effluents mentioned gave the following contents of wool fat and other grease:—476 grains per imperial gallon in the crude suds, 84 grains in the suds after the first skimming, 70 grains in the liquor after settling, and 11.2 grains in the final effluent. The total grease contained in the skimmings was 2268 grains per imperial gallon of the same. The total alkali contained in the crude suds was 70 grains per imperial gallon. In treating these suds sulphuric acid is added, and the amount of such acid in the several effluents was: 150 grains per imperial gallon in the suds after the first skimming 138.6 grains in the liquor after settling, and 21.0 grains in the final effluent. The total acid contained in the skimmings was 58.8 grains per imperial gallon of the same. It may also be noted that 1 grain per imperial gallon is equivalent to 14.286 parts by weight per million.

Two other analyses of crude wool-washing suds are given by Naylor (l. c.) on pp. 77 and 96. The first is:—Total sediment 8380 grains per imperial gallon, containing 1340 grains inorganic matter and 7040 grains organic and volatile matter; total solids in solution 5920 grains per imperial gallon, containing 2640 grains inorganic matter and 3280 grains organic and volatile matter; alkalinity as sodium carbonate 132.5 grains per imperial
2005 gallon; free ammonia 3.64 grains; albuminoid ammonia, 4.20 grains; and grease 635 grains per imperial gallon. The second analysis is: dissolved mineral matter 0.87 per cent., insoluble mineral matter 0.32 per cent., organic impurities 0.96 per cent.; grease 2.02 per cent, and water 95.83 per cent; total 100 per cent.

In a paper on the Pollution of Streams by Manufactural Wastes, by H. W. Clark in the "Journal of the New England Water Works Association," December 1901, Vol. 15, pp. 500-513, it is stated that

ordinary domestic sewage contains from 500 to 1500 parts per million, whereas the liquid wastes from three woolen mills in Massachusetts contained respectively 25,000, 21,470 and 75,000 parts per million.

In another paper on the disposal of factory wastes by Mr. Clark, in the Report of the Massachusetts State Board of Health for 1909, pp. 358-364, reference is made to the effluents from 4 woolen mills, ranging in volume from 30,000 to 4,906,000 gallons per day. The wastes from Mill No. 1 were the waters used in washing woolen cloth before and after dying; they ranged in quantity from 150,000 to 200,000 gallons per day, and were heavy, soapy and very turbid; lime was used for coagulation and precipitation at the rate of 1.5 to 2.5 tons per million gallons.

Mill No. 2 had four classes of wastes, viz: Wool-scouring, spent dye liquor, wash water, and the wastes from the shoddy mill. The latter was from 36,000 to 100,000 gallons per day; the spent dye liquor and wash water were nearly equal in volume and amounted together to from 1,650,000 to 2,300,000 gallons per day; the very objectionable scouring wastes were from 557,000 to 1,033,000 gallons per day and contained much organic and mineral matter in both solution and suspension; and the total volume was from 3,400,000 to 4,906,000 gallons per day.

The wastes from Mill No. 3 came from washing, boiling and dyeing woolen cloth, in the proportion of 1 of dye liquor to 13 of wash water; the total volume was from 30,000 to 35,000 gallons per day. The wastes from Mill No. 4 came from washing woolen
2006 cloth and dyeing raw cotton; the wash-water was from 30,000 to 40,000 gallons per day, of which from 12,000 to 15,000 gallons was very soapy; the dye wastes and rinsing water were 21,000 gallons per day, of which 12,000 gallons were very foul; the total volume of wastes was from 51,000 to 61,000 gallons per day.

In relation to the quantity of water used in scouring raw wool, Mr. Clark gives on page 351 (l. c.) the following figures derived from several woolen mills in Massachusetts. First, for water used in scouring alone, the volumes were: In Plant No. 1, 1.6 gallons; in Plant No. 2, 0.31 gallons; in Plant No. 4, 3.7 gallons; in Plant No. 6, 0.56 gallon; in all cases per pound of wool scoured. Second, for water used in both scouring and subsequent washing, the volumes were: in Plant No. 4, 57.7 gallons, and in Plant No. 5, 68 gallons per pound of wool scoured. These figures indicate that vastly more water is used in washing the material after scouring than in the preliminary scouring process.

Commenting on these figures, Prof. L. P. Kinnicutt, of Worcester, Mass., stated in the Journal of the New England Water Works Association, Vol. 15, p. 511-512, that he had recently observed the process of wool-scouring in Bradford, England, and found that in one large woolen mill 1.2 U. S. gallons of water were used per pound of wool. The writer was also informed very recently by Leonard Metcalf, C. E., of Boston, Mass., that he had examined closely the quantity of water used in scouring wool in a New Eng-

land city, and had found it to be from 1.0 to 1.5 gallons per pound of wool scoured in the first process; also that in the best practice, as much more water was used in the second washing of the wool, and that a far greater quantity was used in mills not carefully managed. Some of the effluents are used over again.

Other estimates of volume of water used in woolen mills are as follows:—In his book on the "Disposal of the Sewage of Industrial Cities," Berlin, 1909, p. 334, Schiele gives the data pertaining to Butterworth & Sons' large woolen mill in Norden, near Rochdale, England. This establishment makes about 8,200 yards of flannel per day and discharges about 95,100 U. S. gallons of liquid
2007 wastes per day, whence the rate is 11.6 gallons per yard of flannel made. (The weight of flannel cloth 30 inches wide is about 3 yards per pound, as given by Dr. H. McL. Wilson in a report made in July 1900 to the West Riding Rivers Board, the figures being 18 lbs. for 50 to 60 yards of flannel 30 inches wide; hence the quantity of wastes would be about 35 U. S. gallons per pound of such flannel. The wastes of this mill must be well purified before discharge, so that there is a strong inducement for economical use of water. E. K.)

In their large treatise on Water Supply, Paris, 1906 Vol. 2, p. 8, Debauve & Imbeaux state that 120 U. S. gallons of water are required in the manufacture of one pound of woolen cloth. The same estimate is also given in the German Engineers' Manual "Hütte," Vol. 3, p. 203. Schiele states on page 339 (l. c.) that in washing or scouring wool, about 16 per cent. of the weight of the hairs is lost in the wastes.

Carpet and Shoddy Mill wastes are also referred to by H. W. Clark, in the Report of Massachusetts State Board of Health for 1909. As wool is largely used as a raw material, such factories are here classed as woolen mills. On page 365 it is stated that the wastes from a Carpet Mill were derived from the processes of scouring wool, yarn, etc., and that they were heavy, soapy liquids or semi-emulsions of fat, soap and dirt, containing solids to the extent of from 20,000 to 30,000 parts per million by weight. These figures indicate that such mill-wastes contain from 70 to 100 times as much solid matter as the ordinary domestic sewage of cities in Massachusetts. It is very difficult to treat these foul liquors. In regard to quantity, it may be stated that in 1904 the volume of liquid waste from this mill was 83,570 gallons per day, and in 1908 it had increased to about 112,000 gallons per day.

On page 397 reference is made to a shoddy mill in which woolen rags were extensively used. The wastes result from the processes of washing, carbonizing and dyeing the rags, in which sulphuric acid, lime and other chemicals were used. Some of the liquid
2008 was very dirty, and the average discharge contained 717 parts solid matter per million, of which 369 parts were lost on ignition. In volume these wastes were from 60,000 to 70,000 gallons per day.

Yeast Factories.—Mr. Clark also refers on page 387 of the above-named report to the wastes from a plant where yeast was made at

the rate of 2000 lbs. per day, and discharging 16,000 gallons of liquid wastes per day. The rate of waste liquid to finished product is thus 8 gallons per pound of yeast. The material is made from molasses and barley malt.

Concluding my answer to the question: I would say that the foregoing constitutes a brief outline of my studies on industrial wastes in relation to municipal sewage from a quantitative point of view, and embraces but little of my investigations on the subject in regard to the quality or chemical nature of such wastes. Much more might be added about the wastes from metal works and mines. Many difficulties in the treatment of these industrial wastes have come under my observation during the past thirty years, and I have found in many cases the effluents from various methods of treatment still contain considerable organic matter, which is left for further purification to the natural processes of decomposition by the plankton or minute living organisms of the bodies of water receiving such effluents. For this reason I have regarded the plankton as an important agency in the purification of polluted waters.

Q. Have you made a special study of the plankton of of fresh and brackish waters, and the processes of so-called self-purification of polluted waters, and, if so, state what studies you have made and with what results?

A. Yes, sir. The studies that I have made of plankton began in 1876, in connection with attempts to ascertain the cause of various disagreeable tastes and odors of drinking water and have continued up to the present time. I soon found that this study involved a good knowledge of the minute organisms of the vegetable and animal kingdoms of nature, namely the protophytes and protozoa, and hence I took up the microscopical study of numerous aquatic organisms of these kinds. Little was then known of the action of bacteria, and when a more extensive knowledge of
2000 these organisms became available in 1880, I began to study bacteriology and have endeavored to keep myself informed of all important advances in this science with reference to water supply and sewage disposal. For many years it was generally believed that the purification of polluted water was accomplished wholly by bacteria, but I had observed early in my studies that much work of purification was done by the protozoa and minute plants more highly organized than bacteria, and urged other investigators to give more attention to this action. I found that my views were shared by many others at home and abroad, and the result has been the establishment of aquatic experiment stations in several countries, from which a much broader knowledge of the process of self-purification of polluted water has now been gained.

It has been estimated that polluted water is inhabited by many other minute living organisms than bacteria, and that all of them play a part in the transformation of organic matter into an ultimate elementary or mineralized condition. These minute organisms are generally much larger in size than bacteria, and embrace both plants and animals with limited powers of locomotion which

remain in suspension in the water between its surface and the bottom but drift about involuntarily with currents. They constitute what is called "plankton," in contradistinction to the living vegetable and animal organisms that remain fixed or crawling in and upon the bottom of the body of water, and which are called generically "benthos."

The vegetable component of the plankton is the fundamental food supply for aquatic animal life. It is derived from the products of the decomposition of the albuminous matter that finds its way into the water from decaying animals and plants, as well as from sewage. The plant builds up complex organic matter by assimilating various elementary substances that have been produced by bacteria and chemical action, and a portion of this vegetable organic matter becomes the food of the protozoa or minute animal components of the plankton, which in turn serve to nourish the larger aquatic animals up to the fishes. The two principal components of the plankton may therefore be classed respectively as food
2010 producers and food consumers.

The plants of the plankton are mostly algæ of unicellular and filamentous form, such as diatoms and confervæ, and contain coloring matter of various hue. A vegetable cell is a mass of protoplasm enclosed by a comparatively dense skin or membrane. By the stimulus of sun-light this protoplasm, or some part thereof, is enabled to dissociate carbon from the carbonic acid dissolved in the water, and to cause this carbon to combine with nitrogen, hydrogen, oxygen and a few other elements contained in the water to form albumen and other complex organic matter. This synthetic process in which oxygen is dissociated from carbonic acid and liberated in the form of gas is called "assimilation;" and the oxygen thus liberated, in conjunction with that which is absorbed directly from the atmosphere, serves both to "aerate" the water and to oxidize dissolved organic matter contained therein.

It is also know that in addition to the matter obtained by assimilation the plants of the plankton absorb certain albuminous or nitrogenous and carbonaceous compounds which are found dissolved in the water; furthermore, that when carbonic acid is rigidly excluded from the water in experimental tanks, these plants can digest certain dilute fatty acids, skatol, urea, peptone and other organic substances; and quite recent experiments mentioned by Marsson in Heft 14 of Reports of the Royal Testing State for Water Supply and Sewage Disposal, Berlin, 1911, have proved that certain diatoms, especially some of the marine varieties, were entirely devoid of chromophyll and subsisted exclusively on the products of decomposition derived from their surroundings without recourse to assimilation. Such algæ are therefore true saprophytes, or residents of putrefying organic matter in water. This direct absorption of dissolved organic matter by algæ is a highly important feature in the self-purification of polluted waters.

The action of bacteria, or microscopic schizomycetes in polluted water is somewhat obscure. These plants do not assimilate inorganic matter as previously described, but subsist wholly by absorb-

ing dissolved organic matter or products of decomposition,
2011 and in this process a consumption of the dissolved oxygen in the water is involved. Their most important function is to liquefy dead organic matter by their excretions and render it capable of being absorbed by other species of living plants. They seem to decompose nitrogenous or albuminous substances by abstracting ammonia therefrom, which is then oxidized to nitrous and nitric acids by other bacterial products or processes, and these acids in turn combine with soluble alkaline bases to form nitrites and nitrates which are important food materials for other plants. Other bacteria have the ability to deal with compounds containing phosphorus and sulphur, and render these elements capable of being absorbed by plants and animals. If the supply of dissolved oxygen in the water is not adequate for all these processes, some of the bacteria will abstract the oxygen that has previously combined with ammonia to form nitrites and nitrates, leaving the nitrogen to escape into the air or become dissolved in the water. This free nitrogen, however, is not utilized in appreciable degree for the structure of aquatic plants.

Bacterial processes in polluted waters are called fermentations. They are divided in general into two classes, aerobic and anaerobic, according as they are performed by organisms requiring a supply of dissolved oxygen in the water, or by other organisms which do not require such oxygen. The first class proceeds rapidly in comparison with the second class which proceeds slowly. So long as an ample supply of dissolved oxygen is available, the first or aerobic fermentation is usually not attended with products of decomposition that are offensive or dangerous to public health and to fish. On the other hand, when the supply of oxygen is deficient or becomes exhausted, the second or anaerobic fermentation is established by another variety of bacteria, with a resulting evolution of offensive and dangerous products in the water. The details of these processes are set forth by Dr. W. E. Adeney in Appendix VI of the Fifth Report of the Royal Commission on Sewage Disposal, London, 1908, and also in a number of other recent publications.

2012 When the supply of oxygen during fermentation is wholly drawn from that which is dissolved in the water, the change in the chemical nature of the organic matter proceeds in two distinct and progressive stages. In the first stage the greater portion of the carbonaceous organic matter that is capable of further oxidation becomes converted comparatively soon into carbonic acid, water, ammonia and excretory substances; while in the second stage the nitrogenous matter, ammonia and excretory substances are slowly fermentated and converted into nitrites, nitrates and relatively small quantities of carbon dioxide. These two stages are called the "carbon fermentation" and the "nitrogen fermentation" respectively. The rate at which the first proceeds depends upon the composition of the organic substances in solution, and also on the action of enzymes, or excretory products of bacteria, in breaking down these substances or rendering them simpler in chemical composition. Thus certain albumens, fats and vegetable oils must un-

dergo such enzymic change before they can be attacked rapidly by the fermentative processes of water bacteria. It may also be added that all these processes take place much more actively and quickly in the warm season in cold weather.

Foremost among the filamentary algae of the planktons of polluted waters are the species called Sphaerotilus natans, Leptomitus lacteus and Beggiatoa. They are found in all places where extensive processes of decomposition occur in water, and especially at the points where liquid wastes containing much nitrogenous organic matter are discharged. Such liquids are the sewage of cities, and the wastes from sugar, starch, glue and cellulose factories, breweries, distillieries and various other industries. The stronger the pollution, the greater will be the development of these organisms. The Beggiatoa thrive only in running water where a supply of oxygen is available, and where sulphuretted hydrogen is present as the product of the putrefaction of albuminous substances derived from either vegetable or animal matter; they separate the sulphur from this gas and store it in their cells. Sulphur is an important source of vital energy for these plants, and serves the same purpose as carbon for other organisms in the process of transpiration; it is, however, not assimilated, but becomes oxidized into sulphuric acid by the oxygen present in the water, and this acid then combines with lime in solution to form gypsum.

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When found in large quantity in a stream, the various fungi (or varieties of algae) first mentioned afford reliable evidence that the water has been polluted in higher degree than usual under natural conditions, and serve as guides to the source of the contamination. They have a great purifying power, but they become entirely inefficient in places where much marsh gas rises from decomposing mud. The algae of the plankton are thus useful indexes of pollution, and enable us to form a correct opinion as to the quality of the water much more quickly than by means of chemical analysis.

In regard to the quantity of living vegetable plankton produced in fresh-water, it may be mentioned that in a single draft of a plankton-net from a depth of only eight feet in Great Plöner Lake in Prussia, about 16,000,000 diatoms of the species Melosira laevissima were obtained; while in the flowing water of the River Elbe near Hamburg, 33,650 algae cells per cubic centimeter were found under relatively unfavorable conditions A still greater number was observed in the greenish water of Lietzen Lake, in which about 400,000 algae cells per cubic centimeter were estimated as being present, according to Marsson. Many other instances of similar character might be cited, but doubtless the foregoing figures will suffice to show the magnitude of the work done by the vegetable component of the plankton in purifying our fresh-waters.

The animal component of the plankton is also an important factor in the self-purification of polluted water, as many of the protozoa and higher forms of animal life thrive on dissolved organic substances by absorption like the plants. The main difference between animal and vegetable organisms is that non-parasitic animals have a mouth-cavity into which they can take solid food, whereas

true plants are nourished exclusively by dissolved matter. It seems to be the function of the protozoa to eat the bacteria and
2014 other minute algae which develop in polluted water, and to serve as food in turn for higher organisms, such as the minute crustacea. These latter in their turn become the food of still higher forms of animal life, and so on to the highest aquatic creatures. The plankton thus forms the beginning of the syclical course of matter terminating in a fish or a whale, and it occupies an important place in the economy of nature.

It must not be understood that all of the constituents of the plankton are to be found in the same locality in a body of polluted water. Each variety selects the habitat that is most favorable for its existence, and predominates over its allied forms. Most of the organisms, both plants and animals, require more or less dissolved oxygen in the water, and as little such is found in sewage or strongly polluted industrial wastes, it follows that different varieties of organisms will be found predominating at different distances from the source of pollution. In general, three stages of decomposition of putrescible organic matter in water can be distinguished, corresponding to the same number of areas or zones which are characterized by the presence or predominence of particular organisms, as follows:

a. The sewage zone, with poly-saprobic organisms;

b. The transition zone, with meso-saprobic organisms;

c. The clear water zone, with aligo-saprobic organisms.

Poly-saprobic Zone.—This zone is characterized by the multitude of Schizomycetes, and bacteria-eating Flagellata and Ciliata. The number of living bacterial germs in such water, as found by growth on ordinary nutritive gelatine, may easily exceed a million per cubic centimeter. In the presence of numerous poly-saprobes, Bacterium Coli need not always appear plentifully, as in the case of the wastes from a sugar or cellulose factory, instead of domestic sewage. The most numerous and most widely distributed organism in the sewage zone of a river is usually Sphaerotilus natans, which forms a slimy, whitish and fleecy lining of the shores. The sulphur bacteria are also found abundantly in this zone, on account of the presence of sulphuretted hydrogen, which is usually decomposed rapidly
2015 in a flowing stream. It may, therefore, be said that the sewage zone is characterized by shaggy or fleecy growths.

From a chemical standpoint, this zone is also marked by the predominance of reducing and splitting processes, due to lack or insufficient supply of dissolved oxygen and to the excess of carbonic acid; also to its relatively high content of multi-molecular, nitrogenous and decomposable food matters, such as peptides and amino-acids, which is indicated by the growth of certain organisms that may be regarded as living reagents.

The mud zone usually rich in iron-sulphide; and if it is also putrescible, it *a* may affect the superincumbent clear water injuriously by the continual liberation of substances which will retard the process of self-purification. After the putrefaction of the mud has ceased, the iron of the sulphides will generally be found as ferric oxyhydrates This change, however, takes place slowly, as much

oxygen is required to complete the process and the supply thereof at the bottom is generally small.

The designation "poly-saprobic" relates to the quality of the food water, although its quantity also comes into account, as it must be sufficient to supply the various poly-saprobic organisms. If only a small amount of sewage is discharged into perfectly pure water, the process of self-purification may begin with the meso-saprobes, as these organisms may then obtain the food which would not be available to them in ecological competition.

In the poly-saprobic zone, we must discriminate sharply between putrescible water (sewage), and water containing putrescible matters which, owing to their small quantity, are not sufficient to induce primary putrefaction therein (river water). In the former, when left to itself, there will be at first a turbulent putrefaction, and then a slow mineralization; while in the latter there will be no putrefaction but a rapid mineralization, owing to the presence of an extensive series of organisms found in natural waters. For this reason the process of decomposition in diluted sewage will never have the same intensity of purification as that of properly managed biological beds,
which are able to complete the process of putrefaction of
2016 undiluted sewage within ten minutes.

The intermixture of sewage with the river water is a highly important factor, but unfortunately it is not available at all points of a river's course. Thus, in the reaches of the Elbe, above Hamburg, there are many lateral tributaries, both sewers and natural streams, whose waters flow along the shores for long distances without mixing with the main body of river water. A conspicuous instance of this kind is the water of the River Saale, which contains a large amount of sodium chloride, and can be traced almost as a distinct stream from its mouth at Barby down to Magdeburg along the left bank of the Elbe.

Meso-saprobic Zone.—In the meso-saprobic zone of a river, the process of dissociation or decomposition has advanced to an intermediate degree. For convenience this one will be divided into two parts, called A-meso-saprobic and B-meso-saprobic, the first extending up stream and adjoining the poly-saprobic zone, and the second extending down stream and adjoining the clean water or aligo-saprobic zone. The first part is usually characterized by the appearance of Schizophyceae and Eumycetes, along with Anthophysa vegetans, Stentor coeruleus, Carchesium lachmanni, etc. The water still contains many bacterial germs, reaching in number hundreds of thousands. Drainage ditches carrying imperfectly purified water are good examples of A-peso-saprobic zones.

The second part, or B-meso-saprobic zone, is generally distinguished by its contents of Diatomaceae, Bacillariaceae and certain Chloropyhceae, along with Rhizopoda, certain Ciliata, Vermes, numerous Rotatoria, etc. The number of bacterial germs growing in ordinary gelatine will usually be less than 100,000 per cubic centimeter of the water. Drainage ditches carrying well purified water will serve as examples of B-meso-saprobic zones.

The organic life in the entire meso-sabrobic zone is usually nu-

merous and widely diversified; the number of its characteristic vegetable and animal organisms is about 400; and it is much richer in highly organized forms than the poly-saprobic zone.
2017 Many kinds of fish thrive in it, as they find therein an abundant supply of food; all of them can endure a small amount of sewage and the products of its decomposition, and many species exhibit a preference for it.

From a chemical point of view, the processes of oxidation in the water and mud are pre-eminently characteristic of this zone. The quantity of dissolved oxygen in the water is considerable; but during dark nights it may decrease largely, especially in the A-section, while during bright sunshine it may often attain a degree of super-saturation.

The nitrogenous food matters that are of importance for the development of most of the organisms in both parts of this zone are included in the compounds found between aspargin and urea, and also the ammoniacal salts of organic acids. Ecologically, peptone organisms are not to be expected here. My observations indicate that asparagin can still be utilized by Leptomitus lacteus, which belongs in this zone, while those of Treboux show that organic acids are absorbed by numerous species of Chlamydomonas, Scenedesmus acutus and organisms similar to Stichococcus, etc. A certain likeness, and in some cases a remarkably great one, thus exists in the physiological nutrition of algae and fungi, and in part also of bacteria; and although it had not then been established by many observations, this likeness was used by Pettenkofer in 1891 for the purpose of explaining the self-purification of waters.

It may be conjectured that certain components of the plankton are associated with definite bacteria, which participate in consuming the same organic food. In studying the problem, it is therefore necessary to determine the number of plankton algae per cubic centimeter of the water, as well as the number of bacteria, and also the number of bacteria-eaters therein which are important from a hygienic and ecological point of view. In examinations of many different waters where a plankton chamber having a capacity of 1 cubic centimeter was used, it was found that there were often a greater number of algae cells than bacterial germs in the
2018 water of certain rivers, lakes, etc. The results of some of these investigations are as follows:

Number of Cells of Plankton Algae per Cubic Centimeter.

Weissen Lake near Berlin, (*a*) of Chlorella, about	1,000,000
Lietzen " " " (*b*) of Oscillatoria Agarch., about	400,000
Hundekehlen " " of Eudorina and Stephanodiscus about	7,000
Waun " " " of Melosira granulata, etc., about	70
Small pond in Riesengebirge, of Desmidiaceae, about	6
Teltow Canal near Berlin, of Melosira granulata, about	154,000
Upper Spree " " of Asterionella and Diatoma, about	200
Elbe River, near Schmilka, of mostly green algae, about	14,500
" " " Pirna, of various kinds, about	200
Rhine " " Assmannshausen, mostly Oscillatoria rubescens, about	100
Neisse " " Forst, of various kinds, mostly green algae, about	40
Eder " " Herzhausen, of various kinds, mostly green algae, about	10

(NOTE.—In the foregoing list (*a*) denotes the A-meso-saprobic zone, and (*b*) the B-meso-saprobic zone.)

It should also be stated that in almost every case there were some bacteria-eaters, even though small in number, in every cubic centimeter of the water. A more detailed account of the significance of the minute plankton life in the self-purification of waters is given in Heft 14, Mitteilingen der Königlichen Prüfungsanstalt zu Berlin, 1911.

By their physiological relations of nutrition to certain chemical substances, both bacteria and eu-plankton are strong reagents,
2019 and are therefore used advantageously in the estimation of the quality of waters. While purely chemical analysis permits only tenths of a milligram of many substances to be determined with great care in a liter of water, the bacteriological and planktological mode of analysis gives reliable and in some cases numerical results with much smaller quantities of material in the water, because in this method a milligram of chemical substance produces a visible effect on thousands and even millions of individual organisms which can be imprisoned and counted in suitable media.

Oligo-Saprobic, or Clean Water, Zone.—The hygienic interest in the disposal of sewage generally terminates at this zone, while it begins therewith in the case of domestic water supplies taken from surface-water sources. The chief characteristic of this zone is the completion of the process of mineralization; all of the more or less turbulent processes of self-purification are absent in the water itself, and the biological development is usually extensive. The appearance of certain representatives of the Peridiniales, all Charales, and certain planktonal Ciliata, Rotatoria and Crustacea, are to be regarded as characteristic.

The number of bacterial germs growing in ordinary nutritive gelatine are usually less than 1,000 per cubic centimeter, provided that the water does not contain erratic forms that have been washed into it by local freshets. The paucity of planktonal Schizomycetes is another characteristic, as well as the absence of poly-saprobic forms. Clean lakes, whose waters do not undergo the special process of mineralization, are included in this zone.

From a chemical point of view, it should be noted that the water does not usually contain more than 1 or 2 milligrams of organic nitrogen per litre, and that the amount of organic matter, as measured by the consumption of potassium permanganate, is small unless it is derived from bogs. The variation in the amount of dissolved oxygen is also small.

As quickly progressing transformations of organic substances do not govern the chemical actions in this zone, the mineral matters,
such as those that define the hardness of the water, may have
2020 an influence on the ecological composition of the organisms. Salts of iron and manganese may be fixed or absorbed in a remarkable manner by iron bacteria Chlamydothryx, Clonothrix and Siderocapsa.

The waters of this and the preceding zones have an alkaline reaction unless they contain a particularly large quantity of carbonic acid or humic acid. Specific organic nitrogenous food substances should be present only in small traces, or be entirely absent, as has

already been stated; on the other hand, inorganic salts of ammonia and sometimes also their different stages of oxidation will generally be found in the water.

The transparency of the water, as measured by the depth at which a white disk is still visible, is usually considerable, except during the time when the water "blooms," or an extraordinary development of algae takes place, in which case it tends to resume its previous B-meso-saprobic condition. The mud below the purified water will have a B-meso-saprobic character, and at times also a A-meso-saprobic one. The lower organisms on the shores will generally be such as form organic mats or felts of a muddy-earthen nature, but they will not be slimy as frequently found in the two preceding zones. The sedimenting pseudo-plankton is readily incorporated or "agglutinated" in this felt.

If erratic additions from local freshets are disregarded, the organisms of this zone are usually harmless in a hygienic sense.

Summary.—In summarizing the various factors that are effective in the biological self-purification of water the following points will be recognized:

1. Splitting and reduction of organic substances by bacteria;

2. Oxidations by transpiration and allied processes;

3. Removal of dissolved organic food matters by fungi and algae, and the transformation thereof into living matter;

4. Consumption of organic solid fragments by animals, or the transformation of such matter into living substance by detritus- and carrion-eaters.

2021 The organisms participating in these four processes are exciters of putrefaction and also reducers thereof. They finally accomplish mineralization by removing the dead substances.

5. Destruction of aggregations of bacteria (including pathogenic ones) and algae by various bacteria-eaters.

6. Destruction of small crustacea, etc., by fishes.

The two processes indicated in 5 and 6 govern the circulation of living matters. Although millions of minute crustacea may be necessary to supply the food for young fishes, thousand- of millions of microscopically small organisms are required for the nutrition of the crustacea.

7. Production of oxgyen by chlorophyllaceous organisms, which serve to aerate the water and remove carbonic acid.

8. Aeration of decomposable sediments by animals that burrow in the mud and sludge.

The two processes indicated in 7 and 8 govern or accelerate self-purification.

The most ideal purification of the water would be accomplished by the gasification of the matters contained therein. This takes place now to considerable extent, as the following gases escape from the water into the atmosphere: CO_2, NH_3, H_2S, N,H, and CH_4. Many winged insects also emerge from their aquatic larvae.

The inter-action of these different processes is required for rapid self-purification. The question also arises whether a fairly progressive purification is possible with only a certain number of varie-

ties of organisms in operation. Based on observations of the processes of putrefaction and those that take place in biological beds, this question may be answered affirmatively, by stating that the Schizomycetes alone appear to be able to purify or mineralize turbid sewage satisfactorily, although slowly. It is also surmised that the same result will be obtained with various Algae provided that the sewage is first clarified by filtration, the order of sequence being:
Phormidium autumnale, Oscillaoria limosa, Nitzechia pales,
2022 Navicula crytocephala, Stephanodiscus Hantzschianus, Stigeoclonium tenue, Scenedesmus bijugatus, Rhaphidium polymorphum, etc. In this series it must probably be assumed that each preceding species leaves behind it those particular food matters which are best adapted to the next following species. It is very doubtful if animals alone, such as Bodo putrinus, Colpidium colpoda, Anthophysa vegetans, etc., can perform the process of purification in all of its phases, especially the first one, because even the lower forms seem to depend mostly on solid food, and especially on bacteria.

The foregoing statements relate mainly to fresh-water plankton, and have been derived from numerous publications, in addition to many personal observations and experiments made during the past thirty years. Among the most recent publications that I have studied on this subject are the Reports of the Royal Testing Stations for Water Supply and Sewage Disposal, Berlin, Heft. 1-15, 1902-1911; Internationale Revue der Gesamten Hydrobiologie und Hydrographie, Vols. 1-4, 1908-1911; Handbunch der Hygiene by Rubner, Gruber and Flicker, Vol. 2, Part 2, entitled "Wasser und Abwasser," and particularly the Section written by Dr. R. Kolkwitz of Berlin on the "Biology of Water, Sewage and Outfalls," pp. 337-387, Berlin, 1911; and "The Inland Lakes of Wisconsin," by Drs. Birge and Juday, Wis. Geol. and Nat. Hist. Survey, Madison, 1911.

In regard to the plankton of brackish and sea-water I have studied the large treaties entitled "Planktonkunde" recently written by Dr. A. Steuer, Leipzig and Berlin, 1910, along with numerous articles in the 11th Edition of Encyclopedia Britannica, 1911, Internationale Revue der Gesamten Hydrobiologie und Hydrographie, and other publications; and the results of this study, combined with my own observations, are as follows:

In regard to the survival of the plankton of fresh-water rivers on reaching the salt water of the ocean, it may be said in general that only such organisms can be expected to survive as are able to adapt themselves to considerable variations in the character of their surroundings. For this reason the organic life in salt waters is
2023 usually less abundant than that in fresh water, although in some salty inland lakes large quantities of plankton are occasionally found. Such plankton consists firstly of those fresh-water organisms which can exist in salty water; secondly, of those forms which have hitherto not been found in either fresh-water or the ocean; and thirdly, of some of the essentially marine forms. It is known that numerous species which belong to fresh-water are able to live in salt water, and the origin of many of the organisms of the

second class has been traced to certain fresh-water varieties; but much doubt has been expressed about the ability of truly marine organisms to exist in brackish water.

It cannot, however, be denied that the organisms of many salty inland lakes correspond closely to similar marine fauna. In the Caspian and Aral Seas, Osterfeld found that the phytoplankton was of a marine or brackish-water character, resembling most closely that of the Baltic Sea, although it has a considerable number of local or endemic forms, such as Diplopsalis caspica among the peridinidae, and Cyclotella caspica and Coscinodiscus aralensis among the diatoms. The zooplankton was found by Sars to be a mixture of marine and fresh-water forms, along with a few peculiar varieties such as Cercopagis. Similar conditions were found by West in some of the large African lakes, and by Korotneff in the Baikal Sea in Russia.

Reference may also be made to the interesting changes in the character of the plankton which takes place when sea-water is mixed artificially with fresh-water by means of ship-canals. As a first example of this kind, the Suez Canal may be cited, where the differences in the temperature and chemical composition of the canal waters are so great as to prevent the transit of most of the plankton from the Mediterranean to the Red Sea, and vice versa. In the Gulf of Suez is a marked reduction of the plankton of the open sea; in the Bitter Lakes section, the number of pelagic copepods was much less than at Suez; and the lack of other organisms is proved by the absence of any phosphorescence of the canal waters, although such occurs frequently in both the Mediter-
2024 ranean and Red Seas.

A second example is afforded by the Kaiser Wilhelm Canal, which connects the North Sea with the Baltic Sea across the base of the Danish peninsula, and was opened in 1895. Up to the Spring of 1895, the Canal had been filled exclusively with fresh-water, but when the terminal locks were opened for traffic, the rapid influx of sea-water appears to have destroyed the fresh-water fauna almost completely. With the exception of two insect larvae, no fresh-water animals were found in the entire canal. The fresh-water fish that formerly lived in the lakes at Rendsburg, Andorf and Schirnau, died during August and September, 1895, and floated on the surface in great quantities; only the empty shells of the previously plentiful mollusk Dreyssensia remained; and all the former fresh-water fauna and flora of the canal seem to have disappeared, and to be replaced by marine or brackish-water forms. The canal plankton, however, is much less abundant than in Kiel Bay.

The discharge of the swamps and lakes tributary to this ship-canal brings into it many fresh-water organisms, but the great majority of them seem to die soon afterward. It is also found that in the western portion of the canal, where much land-water enters and greatly reduced the salinity, the majority of the marine organisms brought in from Kiel Bay disappear, and that in general only those species survive which predominate in the eastern portion of the Baltic, where the water is much less salty than in the

western portion. It should, however, be noted that the scarcity of plankton at the eastern end of the canal may not be due as much to reduced salinity, as to the presence of a host of plankton consumers, especially mussels, which thickly line the banks, whereas in Kiel Bay the consumption of plankton is far less.

The best localities for studying the hyphalmyro—(brackish-water) plankton are the deltas and estuaries of large rivers. Although the entering flood tides push underneath the river-water like a wedge, yet there is a considerable inter-mixture of the salt water with the fresh, thereby rendering the estuaries more or less brackish. Both the river and the flood tide constantly carry
2025 along quantities of suspended matter, which settles at the mouth where the velocity is less, and often forms extensive mud deposits that eventually become exposed at ebb tide. These deposits are burial places of many plankton organisms which cannot survive the quick transition from fresh-water into sea-water, and the numerous shells of marine foraminifera, radiolaria and diatoms found in such mud, indicate plainly that much of the plankton belonging to the sea (haliplankton) cannot endure a reduction of salinity.

It thus appears that only a fraction of the fresh-water and marine plankton can live permanently in brackish water, along with a few other varieties that seem to be peculiar to such water. In general, it has been found that marine animals can penetrate farther into fresh-water than fresh-water animals can penetrate into the sea; or in other words, the former can endure less salinity of water more readily than the latter can endure greater salinity. With the phytoplankton, on the other hand, the reverse seems to hold. From numerous experiments, Karsten reached the conclusion that "Media of higher concentration were less dangerous to the cells of diatoms than those of lower concentration," because plasmolysis can be endured for a long time, and also because a vegetable cell is generally able to adapt itself to a higher concentration in the course of time. In January, 1898, he found in the plankton of Kiel Bay numerous fresh-water diatoms that had been carried down by the River Sventine, many of which, like Melosira granulata, exhibited strong plasmolysis, although fully alive. Lemmermann states that Fragilaria crotonensis and Asterionella elongatum are frequently found in brackish coves.

In 1905 Gran enumerated twelve fresh-water forms of diatoms, belonging to the genera Melosira, Fragilaria, Synedra, Asterionella, Tabellaria and Pleurosigma, which he had found in northern sea waters, and in 1906 Lemmermann found in fresh-water 26 species of diatoms that had theretofore been regarded as being exclusively marine forms. Two species of Chaetoceras, viz: Ch. radians and gracile, are considered as being wholly marine, while Chaetoceras danicum and Thalassiosira baltica are regarded as being brackish-water forms. It is remarkable that at the mouths of certain rivers, a distinct plankton of brackish water diatoms does not ap-
2026 pear to be formed, and that the more or less scanty supply of such organisms in the water is derived from the sea.

The fresh-water Schizophyceae seem to be much more numerous than diatoms in brackish-water plankton, as Lemmermann mentions 21 species found therein. As to their numbers in slightly saline water, Hensen estimated that in the water of Stettin Bay there were not less than 1,760,000,000,000 cells of Aphanizomenon flos aquae per square meter of surface at a time when the water was "blooming"; he also found in sheltered brackish coves of the Baltic as many as 8,340,000 Nodularia filaments per square meter of water surface, while in the more salty Cattegat their number was only 1,224,600. Desmids do not go from fresh to brackish water, but representatives of the Zygnemaceae are occasionally found in slightly salt water. It is likely that the filaments of Spirogyra which have been seen a few times in Kiel Harbor are only accidental arrivals, but on the other hand Hensen estimated that in September, 1887, there were 100,000 such filaments per square meter of water surface in Stettin Bay.

Of the Chlorophyceae, about 20 species are now found in brackish water, representatives of the genera Pediastrum and botryococcus being frequently encountered. Hensen estimated that in Stettin Bay there were 1,700,000 cells of Scenedesmus quadricauda and 10,500,000 cells of Pediastrum in every 10 cubic meters of water. It is also singular that of the numerous Flagellata in fresh-water only a very few are found in brackish water; according to Lemmermann, only 21 species have thus far been recognized.

From these observations it may be concluded that the hyphalmyro (brackish water)—plankton is characterized by the predominance of certain schizophytes and the scarcity of flagellates; also, that by the presence of marine algae, it approximates hali-plankton, but differs therefrom by the scanty development of peridinidae (Lemmermann).

Of the protozoa, the infusoria appear to be most prominent in brackish-water plankton. Several species of Tintinnopsis are regarded as pertaining only to such water. Some of the
2027 marine Medusae are able to endure slightly salt water; but the Aurelia aurita found in this kind of water in the eastern part of the Baltic is usually small; Cyanea capillata, which abounds along the entire shore of eastern Prussia, does not appear in the fresher waters of the Bay of Finland; but Crambessa tagi, on the other hand, ascends far up to River Tagus in Spain.

Among the extensive group of Vermes, only the rotatoria seem to occur plentifully in brackish water, and several species are found only therein. Some varieties are able to live as well in fresh-water as in the sea, although Anuraea aculeata, Var. platei, and Anuraea cochlearis, Var. recurvispina, are characteristically marine. In the most highly-diluted eastern, or brackish portion of the Baltic, the following essentially fresh-water forms are found: Floscularia pelagica, Conochila volvox, Asplanchna girodi, Polyarthra platyptera, Triarthra, longiseta, Var. limnetica, Brachionus pala, the typical Anuraea cochlearis. According to Lauterborn, Notholca longispina lives only in those parts of the Bays of Finland and Bothnia where the brackish water has been displaced by fresh-water; and

Pettersen states that Notholca labis is one of the characteristic brackish-water rotifers of the Norwegian fiords. Synchaeta baltica and Synchaeta litoralis may be regarded as typical brackish-water species of the Baltic and North Seas, respectively.

The Crustacean of brackish-water plankton are also peculiar. Among the Cladocera are found both distinctly fresh-water forms like Diaphanosoma brachyurum, Hyalodaphnia and Leptodora, and the marine species Podon and Evadne. In Sweden, the species Podon polyphemoides goes into fresh water; Corniger maeoticus lives only in the Sea of Azov; and at the mouth of the Rio Tocantins in Brazil, Diaphanosoma fluviatile and Moina minuta were found, so that these may be considered as true brackish-water forms. Bosmina maritima is found very much less frequently in the salty western part of the Baltic than in the brackish eastern part, where it is as numerous as the copepoda. At the mouth of the River Schwentine, Kuhlgatz found that Eurythemora affinis was
2028 the only brackish-water species; but according to Timm this species ascends the Elbe to points above Hamburg, and Gurney found it in the estuaries of Norfolk. Other typical brackish-water forms are Popella gurnei, which is found in the Caspian Sea, the Canal du Midi in France, and the Dalmatian shore of the Adriatic; Pseudodiaptomus pelagicus, at the mouth of the Mississippi; P. richardi, P. acutus and Diaptomus henseni at the mouth of the Amazon; P. hessi at the mouth of the Congo, etc.

The extent shrdlu etoain shrdlu Pmfwyp shrdlu now is thetime In regard to the copepoda, Oberg found that those of the Baltic might be divided into four classes, viz: 1. Occasional tramps from the ocean, such as Calanus finmarchicus, and Acartia discaudata. 2. Forms frequently brought in by brackish water, but which cannot develop in Kiel Bay, such as Eurytemora hirundo; 3. Forms frequently brought in from the North Sea, but which become reduced in vitality in the less salty water, such as Paracalanus parvus; 4. indigenous forms, like Pseudocalanus elongatus, Temora longicornis, etc.

Among the decapoda, Ortmann mentions the genus Acetes of the group Sergestidæ, found at the mouths of the Amazon and Ganges, and larvæ of Anomalocaris macrotelsoni and various Pinnotheridæ, also Chlamydolpeon aculeatum and Ogyris occidentalis, found at the mouth of the Rio Tocantins in Brazil. Among the Amphipoda, Vosseler states that Hyperia sibaginis is the only one of this class which can endure the enormous freshening of the sea-water at the mouth of the Tocatins.

The great majority of the components of the hali-plankton found in brackish water, manifestly belong to the forms which are found along the coast and which, from their habitat, are subject to more or less variation in the salinity of the water; but it is also found from Lohmann's studies that many organisms which seem to be exclusively marine such as the Appendicularia, can exist in brackish water. Thus in water containing less than 30 per cent. of the normal quantity of salt in sea-water, 5 species were found, although of

these only Oicopleura dioica appeared to thrive and multiply
2029 greatly. This species cannot, however, be regarded as being essentially a brackish-water form, because it flourishes also in very salty water. Levander states that Fritillaria borealis is also found in the Baltic up to the Bay of Finland.

The extent and physical relations of brackish water regions are as various as the hyphalmyro-plankton itself. They are of small magnitude in the Adriatic at the mouths of Alpine rivers; on the English coast many of the streams are tidal estuaries extending far inland; but the physical relations become particularly complex at the mouths of great rivers like the Amazon, where the incoming flood tide causes the fresh-water to set far back up the stream, so that over a long distance the tidal variations occur with land-water alone, and all the plankton organisms are of the fresh-water kinds.

The large land-locked portions of the ocean, like the Baltic, are more or less brackish, and true hali-plankton finds its way therein from time to time with the inflowing sea-water. The salinity of the Baltic decreases from west to east, and this may account for the comparative scarcity of plankton in the eastern portion, as well as for the fact that the organisms in the western portion are mostly marine, while those in the Bays of Bothnia and Finland have a profuse admixture of fresh-water species.

Aurivillius found that 62 per cent. of all the marine organisms in the Baltic lie west of a line drawn northeasterly through Falster and Darserort.

By reason of this variation in salinity, it becomes possible to apportion the hyphalmyro-plankton to separate regions or zones, each having distinctive forms of organisms. Thus in the lower part of the Elbe, Dahl was able to find only a single brackish water region, extending from the mouth to Hamburg, which was characterized by Eurytemora affinis; above Hamburg, Volk and Timm found that the river plankton was characterized principally by Cladocera, especially Bosmina longirostris-cornuta. At the mouth of the River Schwentine, Kuhlgatz found that even if the quality of the plankton did not vary with the salinity, there was nevertheless a
2030 distinct quantitative dependence. At the mouth of the Rio Tocantins in Brazil, Dahl found five zones as follows: 1. A distinctive fresh-water zone characterized by Diaptomus henseni, and secondarily by Pseudodiaptomus gracilis, which also extends up the estuary Furo Sant Isabel, in the large island named Marajo lying between the Tocantins and the Amazon; 2. An upper, slightly saline, zone characterized by Pseudodiaptomus richardi; 3. An intermediate, moderately saline zone characterized by Pseudodiaptomus crassirostris; 4. A lower zone of oceanic salinity, lying a little beyond the mouth, and characterized by Eucalanus vadicola and the great scarcity of true pelagic organisms; 5. An oceanic zone characterized by Clausocalanus furcatus.

Quantity of Plankton.—The following figures will serve to indicate the quantity of plankton in various waters. In Samoa Krämer found on the average 0.42 cubic centimeters of plankton per cubic meter of sea-water; but at Kiel in the Baltic he found 1.9 to 11.0 cubic centi-

meters per cubic meter. Henson states that in the tropics the average volume of plankton per cubic meter of water was only one-eighth of what was found in the North Atlantic at the banks of Newfoundland, and according to Brandt, the average volume in Kiel Bay is one-half that near Greenland, and ten times greater than that near Messina. This shows that plankton is much more abundant in the cold waters of the North than in the warm tropical waters. In general, it may be said that a square meter of ocean surface furnishes nearly the same quantity of organic matter as an equal area of agricultural land, viz: from 150 to 180 grams.

Marine Bacteria.—In the ocean down to a depth of 200 metres, Fischer found on the average 785,000 germs per litre, or 785,000,000 per cubic metre. Assuming that such a germ or bacterium has a volume represented by a cube whose edges are 0.001 millimetre long, then 1,000,000,000 such bacteria will occupy a space of only one cubic millimetre, and the bacteria contained in a vertical column of sea-water 200 metres deep and 1 square metre in sectional area will have an aggregate volume of 157 cubic millimetres, or 0.157 cubic centimeters. This computation shows how exceedingly small
2031 the volume of this enormous number of bacteria is in comparison with the bulk of the plankton organisms in only a single cubic metre of sea-water.

Plankton Copepods.—The number of copepods, or minute crustaceæ, in the plankton is of the highest significance in regard to the transformation of organic matter in the water. The size of the smaller species is, according to Krämer, such as to require about 10,000 to be packed in a volume of 1 cubic centimeter, and Hensen estimated that if the mean depth of the Baltic Sea be assumed at 20 metres (65.6 ft.) there would be about 1,816,000,000,000 copepods beneath each square kilometer of its water surface, or 90,800 per cubic metre. If all these organisms were fully developed, their weight in dry organic matter would amount to 2782 kilograms per square kilometre, or 0.139 grams per cubic metre of water; but in fact the plankton of the Baltic contains on the average only 0.878 fully developed organisms to one larva, and 3.02 to one egg. The plankton of the North Sea contains a considerably smaller number of copepods, although from 7 to 10 times more than that of the Atlantic.

Plankton Ceratia and Diatoms.—The next most important consumers of the plant food-supply are the ceratia and diatoms. As many as 13 individuals of Ceratium tripos have been found in 1 cubic centimetre of the water of the Baltic. In the Mediterranean Sea near Syracuse, Lohmann found the following numbers and volumes of other organisms per cubic meter of water:

Name of organism.	Number.	Volume in C. C.
Gymnodinidæ	404,250	0.66
Peridiniaceæ	37,450	0.70
Diatoms	1,100,500	10.20

Annual Amount of Organic Matter. Assuming that each copepod eats only 12 ceratia per day, and that there are 1,000,000 cope-

pods underneath each square metre of water surface, the number of ceratia thus devoured per year would be 4,370,000,000, which corresponds to 133.35 grams of organic matter. In like manner Hensen estimated that the average daily yield of diatom plankton in the Baltic was 18 cubic centimeters throughout the year beneath each square metre of water surface, and that this corresponds to from 14.8 to 17.7 grams of organic matter per year per square metre; hence the amount of such matter from ceratia and diatoms in 149.6 grams. An equal area of agricultural land, on the other hand, yielded about 179 grams of organic matter per year. It therefore follows that the former is 80 per cent of the latter, but inasmuch as minimum figures were used in estimating the plankton, it may be concluded that the annual yield of organic matter in the plankton of the Baltic is about the same in weight as that of an equal area of land.

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Similar computations were made by Schröter in regard to the fresh-water plankton of the Lake of Zurich. As mentioned in the foregoing, the volume of plankton beneath a hectare of water surface was found on a certain day to be equivalent to a weight of 430 kilograms of dry matter. On the other hand, a hectare of meadow land adjacent to the like yielded 8470 kilograms of hay having about 14% moisture, or about 7,280 kilograms of dry matter. This would indicate that the land yielded 17 times more dry matter than an equal area of the lake, but it must be remembered that the plankton does not include the fishes, nor the abundant fauna and flora on the bottom; furthermore, the element of time enters into the computation, and the yield of the lake during an entire year is not known.

A more appropriate comparison, in this case, would be with a meadow that yields an equal amount of dry matter as the lake from the same area. Such meadows are found on the Swiss alps, and one of them at an elevation of 2000 metres above sea level yielded only 550 kilograms of moist hay per hectare per year, corresponding to 470 kilograms of dry matter. This agrees very closely with the aforesaid amount of dry matter in the plankton from a hectare of lake surface.

Distribution of Plankton.—In view of the fact that the volume of plankton is by no means uniform in different portions of the same sea in the same month, it has been concluded that the organisms are distributed in swarms, between which comparatively few will be found. More recent investigations, however, indicate that such swarms are not the result of chance, but that they appear annually at the same season and place. Numerous localities in the oceans are known where such developments or aggregations of plankton occur regularly, and Apstein accounts for them as follows: Like all other objects such as leaves, chips of wood, etc., that float in a current, the living organisms of the plankton will tend to drift to the edges of the current, and to settle in the more quiet water. This phenomenon was called by Semper the "self-purification" of the stream or current; and it is due to this action of main, counter and compensation currents that extensive ac-

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cumulations of debris or sargassum occur in various places in the ocean; the same action will also account for the greater volume of plankton found at some places in the open sea as well as near the coast.

Swarms of special organisms have also been observed in bodies of freshwater, and particularly in some of the North American lakes. In 1897 Birge expressed the opinion that such developments probably occurred oftener than had been commonly supposed; and subsequently, after studying recent investigations, Marsh modified his original views about swarms, and conceded that the horizontal distribution of plankton was much more uniform than he had previously assumed. Where swarms actually develop, they are usually due to the crustacea of the limno-plankton. Such swarms of crustacea were observed by Huitfeld-Kaas in Norwegian lakes, in one of these mountain lakes at Gudbrandsdalen, he noticed that on a certain morning in August the Bosmina obtusirostris had gathered together in small masses on the perfectly smooth surface of the water, and floated slowly by his still boat in the form of narrow ribbons. "The Bosminæ were plainly seen as small dark points on the surface of the blue-green glacier water; the same phenomenon was also observed for several days by Grieg at Hauglandsvand,
where large schools of chars (Salmo alpinus) fairly wallowed
2034 in an extensive mass of these organisms on the surface of
the water." A plankton net drawn through the water at this place was immediately filled with these cladocera, but when it was drawn through other places where the fish did not appear, the catch of Bosminæ was so scanty that the individuals could easily be seen with the unaided eye.

The formation of such swarms of limno-plankton is doubtless due chiefly to the action of winds and currents, and also to differences in the intensity of the light at different portions of small mountain lakes; but it is safe to say that the development of swarms, in either the sea or bodies of fresh-water, does not affect appreciably the determination of the quantity of plankton by the methods commonly employed.

Plankton is the permanent food of many small species of fish, and the temporary food of many large varieties in their early stages of life; it also becomes the food of the latter when other material is lacking. This applies equally to fresh-water and marine fishes, so that it can be said that fish will eat whatever is available. Great quantities of plankton are also consumed by whales, seals and birds. The remainder that is not thus utilized by the active inhabitants of the water serves as nourishment for the benthos or sedentary organisms on the bottom, as much of it ultimately settles.

Chemistry and Metabolism of Plankton.—In considering the interchange of matter, as it takes place in open waters, it must be remembered that the organic substances contained in water are in two forms, viz. solid matter in suspension, and dissolved matter. The first embraces the plankton, which may be divided into two main classes, viz: the phytoplankton or food producers, and the

zooplankton or food consumers; and it now becomes of interest to learn the chemical composition of the principal components of the plankton.

All living organisms have a large quantity of water in their composition, and hence it is usual to give figures referred to the weight of dry substance contained in them. The copepods are the principal food consumers, and it has been found that 1 gram of dry
2035 matter results from the dessication of about 162,000 marine copepods, and from 50,000 to 124,000 fresh-water copepods. The chemical analysis of this matter, according to Brandt, indicates the following composition:—59.0% albumen, 4.7% chitin, 7.0% fat, 20.0% carbohydrates, and 9.3% ash; total, 100.0%. Rosenfeld, however, asserts that this percentage of carbohydrates is too great, and that the fat should be increased to 12.5%.

Knauthe gives the following analyses of various other plankton components:

Substances.	Cladocera Sida.	Cladocera Bosmina.	Anabaena.	Peridinidae Ceratium.	Diatoms Chaetoceras.
Albumen	57.3%	72.4%	13.0%	13.0%	10.8%
Fat	7.6%	8.2%	1.3%	1.4%	2.5%
Carbohydrates	....	....	....	80.6%	21.5%
Non-nitrogenous Extractive matter	....	....	39.0%	....	....
Raw fibre	....	....	41.5%	....	....
Ash	21.5%	17.4%	5.2%	5.0%	65.2%
	86.4%	98.0%	100.0%	100.0%	100.0%

The total amount of carbon found on analyzing the entire mass of living organisms contained in one litre of sea-water, was 0.00384 mg., of which 0.00129 mg., or 33.6% was in the form of albumen, and 0.00255 mg., or 66.4% was in the form of carbohydrates and fats; the total amount of nitrogen in the same organisms was 0.00039 mg.

From the foregoing figures we may place:—

1 gram of dry substance = 675,000,000 diatoms, or = 42,000,000 to 65,000,000 peridinidae, or = 300,000 to 500,000 copepods; hence it follows that 1,000 diatoms = 62 to 96 peridinidae = 0.44 to 0.74 copepods.

It may also be noted that the proportion of ash in the dry matter of diatoms is so large, that a comparison based on the remaining matter is very unfavorable for the diatoms, but on the basis of the quantities of organic matter contained in the numbers of the three classes of organisms last stated, they will be in the proportion 34.8:
94.8: 90.7, which corresponds to 2,880 diatoms = 65 to 101
2036 peridinidae = 0.44 to 0.77 copepods; whence 1 average copepod = 135 average peridinidae = 4,720 diatoms, and 1 average peridinium = 34.7 diatoms.

The chemical composition of a few land plants may now be compared with that of plankton expressed in percentage of dry substance as follows:

Substances.	Autumn Plankton.	Peridinidae.	Inferior hay.	Good hay.	Rye straw.	Rye, Green fodder.
Albumen	21.0	13.0	8.7	13.6	3.5	12.0
Fat	2.5	1.3	1.7	3.2	1.5	3.3
Carbohydrates	64.5	....	....	....	....	....
Non-nitrogenous Extractive matter	....	39.0	44.5	48.2	38.8	51.6
Raw fibre	....	41.5	39.1	26.8	51.3	27.0
Ash	12.0	5.2	5.8	8.2	4.7	5.8
Total	100.0	100.0	99.8	100.0	99.8	99.7

This shows that the nutritive value of autumn plankton is nearly as great as that of the best kinds of fodder, and much superior to rye straw. As the raw fibre is composed mostly of carbohydrates, it will be noticed that the peridinidae alone have a food-value equal to that of good hay and green rye fodder. Owing to their large content of silica, the food-value of diatoms cannot be compared directly with that of hay and other fodder, but a comparison can be made of the respective quantities of organic matter exclusive of ash; and it will be found therefrom that the percentages of albumen, fat and carbohydrates contained in diatoms are practically the same as in the best meadow grasses, peas and lupines.

A similar comparison of the chemical composition of marine copepods with that of other marine animals, is also of interest, and is exhibited in the following table:

2037

Percentage of dry matter in—	Albumen.	Chitin.	Fat.	Carbohydrates.	Ash.
Plankton copepods	59.00	4.7	7.00	20.00	9.30
Oysters	46.80	..	9.50	28.10	16.00
Mussels	54.86	..	7.07	26.00	12.00
Crabs	78.87	..	7.69	3.75	9.60
Lobsters	79.80	..	10.13	0.16	9.41
Flounders	87.61	..	4.38	....	8.00
Herring	56.42	..	35.85	....	7.02
Cod	91.08	..	1.86	....	7.60
Salmon	60.49	..	35.62	....	3.89

This table shows that the quantity of albumen and fat is nearly the same in the copepods, oysters and mussels. It must also be remembered that the composition of the different animals varies considerably with their age, as well as with their food-supply and the season of the year.

In general, there seems to be a certain relation between the amount of fat found in the food, and that which is deposited in the body of an animal. The synthetic formation of fat in animals proceeds from the carbohydrates of the plants and other animals consumed as food, while in the case of plants it proceeds from much more elementary substances. The source of all the fats found in both

fresh-water and marine animals is the plant-life of the plankton, and especially the diatoms.

Effect of Fresh-Water on Marine Plankton.—The quantity of plankton in sea-water is locally affected by the admixture of fresh-water from inland rivers when in flood stages, and hence the salinity of the water is an important factor in the development of certain species of marine organisms. An example of this kind was observed by A. Nathanson in the Mediterranean Sea near Monaco in 1909, and was reported by him in Annales de l'Institut Oceanographique, 1910, Fascicule 5, as follows:

During the period from March 22 to April 24 the sea-water was marked by low salinity owing to the copious inflow of fresh water, the minimum inflow being on April 8. From April 24 the concentration began to increase and became normal on May 24. During this period an intense development of Chaetoceras (hairhorn alga) occurred, which attained its maximum when the dilution with fresh water was greatest, and which stopped when the salinity again became normal. Another maximum of Chaetoplankton
2038 occurred at the end of June immediately after a sudden dilution with fresh water.

Conclusion.—All that I have said about plankton in the foregoing will serve to indicate the importance of the aquatic life in bodies of fresh, brackish and sea-water in transforming and utilmately mineralizing the organic substances, liquid and solid, that find their way therein as sewage and industrial wastes. This is of particular consequence in the case of New York harbor, in view of the enormous volume of sewage and wastes produced daily by the huge and rapidly growing population on its shores, the impracticability of wholly excluding such sewage and wastes therefrom and the variable salinity of its waters. The degree of unavoidable pollution of these waters must accordingly be measured by the character of the plankton that is most efficient in dealing inoffensively under the most unfavorable seasonal conditions, with the putrescible organic matters which cannot be excluded.

Q. Have you studied the chemistry of the decomposition of organic matter in waters and the processes of oxidation, and, if so, state with what results?

A. I have given much study to the decomposition of organic matter in fresh and salt water, and have made many qualitative experiments in this direction. In my answer to the preceding question, some of the phenomena of decomposition were described and reference was made to direct chemical actions and biological actions. These are manifold in character, but in general they involve the slow combustion of unstable organic compounds by processes of oxidation, both direct and indirect. Many of the organic substances that are contained in sewage and industrial wastes are highly complex in chemical composition, and when discharged into bodies of water they are acted upon at once by both the oxygen dissolved therein and the bacterial and plankton organisms. Some of these substances will combine directly or chemically with this oxygen, while others must first be simplified in composition by the abstrac-

tion of a portion of their elements by other compounds such as
bacterial enzymes requiring the same, whereby new molecu-
2039 lar combinations are formed which will ultimately assume a
stable character. This alteration of original complex composition is called "breaking down" or "cleavage".

A distinction is often made between the words "decomposition" and "purtrefaction". The former is frequently applied to the oxidation processes of carbohydrates and fatty substances, while the latter relates to the cleavage of the proteid and albuminous substances, or essentially nitrogenous products of animal and plant life. The breaking down of organic matter into simpler substances is mostly effected through bacterial activities. In some instances this takes place in the presence of dissolved oxygen in the water, and the process is then called an aerobic or oxydizing decomposition or fermentation; in other cases it proceeds in the absence of such dissolved oxygen, and is then called an anaerobic decomposition or putrefactive fermentation, it being effected by organisms which thrive in polluted waters devoid of free oxygen. These two processes are also designated simply as fermentation and putrefaction.

The exudations of living bacterial cells, along with certain products of their combination with soluble organic compounds, are called enzymes or soluble ferments. These exudations resulting from the action of the living protoplasm upon the dissolved organic matter which is absorbed by it through its surrounding membrane, are diffused in the water and exert a solvent action upon solid organic substances with which they came in contact; they may also combine with certain dissolved organic substances to form others which possess the property of rendering other solid organic matter soluble. Of the mechanism of these actions, little is yet known aside from the results attained, and the same is also true of the action of the protozoa, or minute animal organisms, which are associated with bacteria in highly polluted water.

In general, these solvent actions upon solid colloidal organic matter in water are called "digestion", and numerous experiments in this direction have been made. The most extensive series was carried
out in 1907 by Dr. W. Favre, at the Hygienic Institute of
2040 Hamburg, Germany, and are described in "Gesundheits Ingenieur", Vol. 30, 1907, pp. 809-816. The substances under observation were albuminous matters, consisting of boiled egg-albumen, raw and boiled flesh, sinews and cartilage of cattle, birds and fishes, also feathers, leather and wool; fatty matters, such as egg-yolk, butter and beef-tallow; carbohydrates, such as cabbage and potato, raw and boiled; and matter consisting mostly of cellulose, such as linen, hemp, twine, paper and cork. Another series of experiments was made in 1909 by the Metropolitan Sewerage Commission in the New York Aquarium, and also in the harbor water at the Battery; and a brief outline thereof is given on pages 461 and 462 of the published report of said Commission dated April 30, 1910. A short series was also made in 1909 by Dr. Spillner of Essen, Germany, and also reported in "Gesundheits Ingenieur", Vol. 32, 1909, pp. 825-828. A fourth series similar in extent to the first, was made

in 1910 by Dr. Guth of Hamburg and Dr. Spillner of Essen, in a number of sewage purification tanks in Germany, and reported in "Gesundheits Ingenieur", Vol. 34 Mar. 4, 1911. The results of all these experiments exhibit much diversity in the rates of decomposition of different organic substances, cellulose being generally the most resistant.

Owing to their importance in the economy of Nature, the phenomena of oxidation have attracted the most attention. Reference has already been made in my previous answers to the oxidizing process called the carbon-fermentation of sewage matter in water, as set forth by Adeney and Letts in Appendix VI of the Fifth Report of the Royal Commission on Sewage Disposal, London, 1908, by which the oxygen dissolved in the water is gradually made to combine with a portion of the carbon in the organic matter and appear as carbon dioxide. The descriptions of the process of combination, however, are obscure, and hence it is necessary to secure information in this respect from other sources. I have therefore studied the process or mechanism of the oxidation of organic matter in several recent treatises on biochemistry, and found the clearest exposition of it in Dr. S. Frankel's "Dynamische Biochemie", Wiesbaden, 1911.

2041 Numerous views of the more delicate mechanism of the oxidation processes in cells have been published, but it should be noted that such views were the more positive in proportion as the knowledge of these processes was the more obscure. The oxygen of the atmosphere is inactive, and cannot oxidize the organic substances which come into consideration for an organism under ordinary conditions of temperature. To accomplish such oxidation the oxygen must be active,—that is to say, the molecular oxygen must be decomposed; and the conditions under which this decomposition will take place are the subject of keen controversy among chemists and physiologists.

Hoppe-Seyler and Baumann conceived that the oxygen was rendered active by certain reducing substances which split the molecule of oxygen (O^2) into two atoms, and then combined with one atom, leaving the second atom free and in a particularly active form which was especially adapted to accomplish oxidation. Nascent hydrogen was thus regarded as the reducing agent that splits the molecule of oxygen and appropriates to itself one atom, leaving the second atom as active oxygen capable of causing eneregtic oxidations.

Radziszewski (Liebigs Annal., Vol. 203, p. 305) called attention to another mode of rendering molecular oxygen active. He had noticed that when a series of substances were saturated with alcoholic potash and warmed, they became strongly phosphorescent, the conditions being the presence of oxygen, akaline reaction and slow chemical action. The substances best adapted to this result were the aldehydes, and the chemical equation which expressed the oxidation of all these aldehydes is analogous to that of the oxidation of phosphorous by having an odd number of atoms of oxygen, for example, R. CHO + O = R. COOH. During the phosphoresence, and also during very slow or very turbulent oxidation, the splitting of the molecules of oxygen takes place; and ozone is not produced only

when the reaction is akaline. All substances which have the property of storing active oxygen will become phosphorescent when
2042 treated with bases. Thus cholin can render fats, cholesterin, etc., luminous.

Radziszewski explains the phosphorescence of organisms through the action of lecithin, fat, cholesterin, wax, sugar, gallic acid, etc., all of which becomes luminous with bases. Cholin and neurin can render fats, terpenes, cholesterin and protagon luminous. A very small quantity of substance is sufficient to produce the effect. Thus 3.79 milligrams of lophin wetted with alcoholic potash will be luminous for 1 hour.

Nencki pointed out that cells produce easily oxidizable matters, and that a portion thereof is oxidized directly by molecular oxygen, whereby atomistic oxygen is dissociated and serves to combine with and burn up the portion that is not directly oxidizable. This process must doubtless take place in the presence of an alkali.

Nasse recognizes two kinds of oxidation. The first is a direct oxidation, which is possible only with self-oxidizable substances, and which proceeds by the direct combination of oxygen with the substance. The second kind involves the dissociation of water, whereby hydroxyl (HO) replaces the hydrogen and two atoms of hydrogen are liberated, which in turn split the oxygen molecule into atoms of oxygen. The latter then accomplish the secondary oxidation which is required for all substances that are not self-oxidizable. Direct oxidation probably does no occur in the body, and the second kind is much more likely to take place. Nasse also regards the first stage of the resolution of glycol as a hydroxylization which can, however, take place only through the mediation of an enzyme.

Traube was among the first to call attention to the action of ferments in oxidations proceeding in animal organisms. To him is due the refutation of Hoppe-Seyler's theory of oxidation by means of nascent hydrogen. His conception of the process is that various inorganic and organic substances act as "oxygen-exciters" by extracting oxygen atoms from various substances rich in oxygen, or so-called "oxygen-spenders", and conveying this atomistic oxygen to other substances which can be oxidized only with difficulty.
2043 The oxidations which take place in a living organism are thus brought about by oxygen-carrying ferments.

Van t'Hoff and Jorissen showed that a slowly oxidized substance rendered as much oxygen active as it took up during the formation of its primary product of oxidation, and hence that a self-oxidizable substance and one which was not self-oxidizable would each take up the same amount of oxygen. This rule, however, applies only when the lower oxide resulting from the super-oxide is permanent and does not act as an oxidizer; but if this lower oxide is able to give off its combined oxygen subsequently, the original self-oxidizable substance will again be formed and be ready to absorb oxygen anew, and thus accomplish the oxidation of other substances. These two investigators assume that the molecule of oxygen is decomposed into its atoms, and that one kind of matter has a preference for one of these atoms, while another kind prefers the other atom, owing to different

electrical charges. The splitting of the oxygen-molecule does not take place first in the oxidation process, but the ordinary oxygen is conceived to be already dissociated into atoms, even though in slight degree, which will cause the oxidation to proceed. This theory, however, does not explain or consider the production of hydrogen-superoxide in the processes of self-oxidation, as Traube showed that active oxygen and water will not form hydrogen-superoxide.

Engler and Bach, following the theory of Traube, assumed further that the first step in the process of slow combustion was the attachment or aggregation of unsaturated molecules of oxygen to other substances likewise unsaturated. The result of this aggregation is considered to be the formation of cumulatively oxidized products like superoxides, which Engler and Weissberg call "moloxides." According to this theory, the substance which takes up the oxygen primarily is called an "auto-oxydator," while the other substance which is not self-oxidizable is called the "acceptor."

The oxygen is supposed to act upon self-oxidizable matter by lodging against it. If this takes place directly, we will have direct self-oxidations or auto-oxidations, and the resulting mol-oxides
2044 will hold the oxygen in a molecularly combined state. Engler's theory thus requires that in self-oxidizing processes the oxygen shall always be taken up in the form of complete molecules instead of separate atoms, since by the splitting of the dual molecule superoxide combinations must result. Like hydrogen superoxide, these combinations are able to give off an atom of oxygen to other oxydizable substances, and thereby to pass into the state of a normal simple oxide. The "active" oxygen is therefore not in the form of free atoms, but is chemically combined with a substance, although easily dissociated therefrom. Engler's theory thus affords a simple explanation of the fact found experimentally by Van t'Hoff and others, that both self-oxidizable matter and otherwise oxidized matter take up an equal quantity of oxygen, since a superoxide combination gives off one atom of oxygen and retains one.

It appears, however, that besides oxidation and reduction reactions, there are in the living organisms other reactions which are simultaneously oxidation and reduction reactions. Thus Abelous and Alois (Comptes Rendus, Paris, Vol. 138, p. 382) have directed attention to certain substances in animal and vegetable organisms, which are able to oxidize salicylic aldehyde.

(OH. C_6H_4CHO) to salicylic acid (OH. C_6H_4COOH), provided that potassium chlorate ($KClO_3$) or similar compounds containing much oxygen are present in the reaction.

It may also happen that an auto-oxydator is at the same time an acceptor, and in this case it is proper to speak of a direct auto-oxidation. To this class belongs the transformation of hydroxylamin (NH_2OH) to nitrous acid (NO_2H) as demonstrated by Binz (Virchow's Archiv., Vol. 113, p. 1), in which a peroxide hydrate is first formed, which gradually changes to nitrous acid by the dissociation of water.

The formation of hydrogen-superoxide in the process of self-oxidation, is regarded by Engler and Herzog as the result of both the

hydrolysis of the peroxide produced by direct self-oxidation
2045 with the secondary formation of hydrogen-superoxide, and the combination of molecular oxygen with reactive hydrogen, so as to form hydrogen-superoxide.

Indirect oxidation is much more frequently encountered. In this process the substance that effects self-oxidation is not the same as that which binds the molecular oxygen, but it is that which causes another substance containing many hydrogen-ions to become an auto-xydator. Engler and Herzog regard the first phase of the biological action of gaseous oxygen as a self-oxidation (Ztschr. f. Physiolog. Chemie, Vol. 59, p. 374).

The concentration of ions of hydroxyl in the tissues and liquids of an organism is of great significance for oxidation and dissociation or splitting. In the spontaneous oxidation of sugar Mathews found (Journ. of Biolog. Chem. Vol. 6, p. 1) that the process takes place rapidly in air if the solutions are alkaline, but not when they are ne-tral or acid; and hence he concludes that the formation of a salt is necessary to accomplish oxidation. This salt becomes ionized, and by the resulting disturbance of electrical equilibrium in the anion, a decomposition or dissociation and easy oxidation will ensue. The speed of the reaction increases as the reaction progresses.

Cystein oxidizes spontaneously at low temperature with atmospheric oxygen and changes to cystin. This oxidation depends on the reaction of the medium, and proceeds best in the reaction of blood, as in the case of protoplasmic oxidation. Small quantities of potassium cyanide and some of the nitrites are able to prevent the spontaneous change of cystein to cystin.

The reducing power of the tissues, according to Ehrlich, depends on their great avidity for oxygen. Frankel and Nogueira succeeded in isolating from kidneys certain phosphatids which quickly reduced methylen blue. Phosphatids saturated with oxygen do not possess
this property in general, but it was found that of three such
2046 unsaturated compounds extracted from beef kidneys the least saturated one caused the strongest reducing action. Similarly with unsaturated substances derived from brain. Fränkel and Dimitz accordingly assume that the reduction of methylen blue is doubtless associated with the unsaturated composition of the fatty collateral compounds contained in phosphatids, but that a special addition to the remaining molecule is need in order to develop an energetic reducing action. They also assume that the unsaturated phosphatids which have an avidity for oxygen bring about the fixation of oxygen in the tissues, and possess a special function in the changes or alternations of reduction and oxidation.

The reductions which the cells are able to perform, are explained by Heffer as being due to the unstable hydrogen of the sulfhydril groups in the proteids; but the same reductions can also be accomplished by unsaturated phosphatids which do not contain sulfhydril groups as shown by Fränkel in conjunction with Nogueira and Dimitz. It may be conceived that the lipoid-soluble coloring matters will form with these unsaturated phosphatids in the presence of water, a system in which the water will be decomposed in such

manner that the hydrogen will be applied to the reduction of the coloring matter, while the oxygen is temporarily fixed to the dual combination of the phosphatid, and is then used up by a substance that is to be oxidized with or without the help of an enzyme, the phosphatid being regenerated during this latter process.

If only an unsaturated phosphatid is present and takes up atmospheric oxygen, it will gradually become resinous and dark in color, thus passing into a condition in which it is never found in a living organism. When such a phosphatid is carefully extracted from the tissues, its color is white, but on exposure to the air it turns brown or black. These unsaturated phosphatids are able to deposit or lodge either molecular oxygen or water at their locus of dual combination, and by such deposit both the dual combination of the oxygen and that of the carbon chain will be broken or resolved. In consequence of this action, a loosening of the atoms of oxygen will take
2047 place, and the active substance will tend to decompose, inasmuch as active oxygen may then be taken away from its combination with an oxidizable substance. Moreover, both of the atoms of oxygen must be taken away from the combination, in order that the substance may be regenerated and enabled to combine anew with molecular oxygen in continuous alternating sequence.

Fränkel's conception of the process is that water lodges at the locus of the dual combination of unsaturated phosphatids of definite constitution, and that the substance to be reduced is held in solution in the principal mass. It is a fact that reducible substances, such as reducible coloring matters, are soluble in phosphatids. In the process of reduction, the hydrate combinations first lose the two atoms of hydrogen, whereby the superoxide is regenerated; in this state the superoxide has exactly the same constitution as that which results from the deposit of molecular oxygen at the locus of the dual combination; hence this superoxide can again give off oxygen and again be regenerated to its original condition of unsaturated phosphatid. Such substances which can perform both oxidations and reductions within the tissues, but possess no enzymic functions, may be designated "intermediary bodies."

The possibility that the sulfhydril group (-SH) of albuminous bodies stands in close relation to the oxidations, as pointed out by Heffter, has been broadened somewhat by a hypothesis presented by Friedländer. This investigator observed that if a current of air is passed through an alkaline solution of acetophenons obtained from mercaptan derivatives, the substances will pass almost wholly into derivatives of thio-indigo. This reaction is readily explained by assuming that the sulf-hydril group is thus oxidized to the sulphide group (-SOH), which must then have the property of parting easily from its oxygen or its hydroxyl (OH). The bisulphides so produced would then not represent the primary products of the oxidation of the mercaptans, but would be the result of splitting off water from one unchanged molecule of mercaptan and from another
2048 molecule of mercaptan which had become oxidized in the sense indicated above. If the assumption is correct that the oxygen in the compound (-SOH) is very easily given off, then the same is to

be expected in the case of sulfoxides. The latter are in fact very easily decomposed; for example the combination (C_6H_5-SO-CH_2-COOH) will yield thio-indigo when treated with fuming sulphuric acid, whereas with the diluted acid it is decomposed to phenylmercaptan and glyoxylic acid. The aliphatic mercaptans doubtless behave similarly, as shown by the easy transformation of cystein to cystin. It is therefore also probable that the sulphur compounds in a molecule of albumen play an important part in rendering oxygen active.

From the foregoing it will be seen that the process of the oxidation of organic matter in water is highly complex, and that chemists have not yet agreed upon a satisfactory explanation thereof. In my opinion Fränkel's conception of the process is preferable to the others.

Q. Have you made a study of the amount of oxygen that the different kinds of water, clean and polluted, will hold in solution, and the rates at which such waters will absorb oxygen from the atmosphere, and, if so, state with what results?

A. I have made such a study from all available data. It is necessary in the outset to distinguish between the quantity of oxygen that different kinds of water will hold in solution when fully saturated with this gas and exposed to the atmosphere, and the rate at which such waters will re-absorb oxygen from the atmosphere after they have lost more or less of their previous contents of this gas in some manner. Free exposure of the water to the atmosphere will be assumed in my answer, as both the quantity of oxygen dissolved and the rate of its re-absorption varies with the pressure of the gas upon the water. The volume of a given weight of oxygen also varies with the temperature and the pressure to which it is subjected; hence it is customary to refer to the volume of this gas when at the temperature of 0°C or 32°F., and under a barimetric pressure of 760 millimeters or 30 inches of mercury. Under these conditions one cubic centimeter of oxygen weighs 1.429 milligrams, or 0.02205 grains; and similarly one cubic foot of
2049 oxygen weighs 40,465.0 milligrams, or 624.45 grains, or 0.08921 lbs. avoirdupois.

Oxygen forms about 21 per cent. of the volume of the atmosphere, while nitrogen forms about 79 per cent. thereof. Air dissolves in water at ordinary temperatures and barometric pressures, but not in proportion to its volumetric composition of oxygen and nitrogen. The quantity of air dissolved or absorbed also varies with the chemical composition of the water, but it is independent of the nature and quantity of other gases which the water may already hold in solution. At 0°C and 760 millimeters barometric pressure one litre of distilled water will absorb from the air 10.24 cubic centimeters of oxygen and 19.30 cubic centimeters of nitrogen, while one litre of pure sea water will absorb 8.18 cubic centimeters of oxygen and 15.60 cubic centimeters of nitrogen. Roughly speaking, while the volumetric ratio of oxygen to nitrogen is 1 to 5 in the atmosphere, it is 1 to 2 in the air which is dissolved in or absorbed by water. For higher temperatures the aforesaid figures change somewhat, as shown in the following table:

Volumes of Oxygen and Nitrogen (Expressed in Cubic Centimeters per Litre and Measured at 0° C. and 760 Millimeters Barometric Pressure) Absorbed from the Air by Distilled Water and by Sea Water at said Pressure, But at Different Temperatures.

(According to Dittmar.)

Temperature in degrees C.	Distilled water. Oxygen.	Distilled water. Nitrogen.	Distilled water. Ratio $\left(\frac{N}{O}\right)$	Sea water. Oxygen.	Sea water. Nitrogen.	Sea water. Ratio $\left(\frac{N}{O}\right)$
0	10.24	19.30	1.88	8.18	15.60	1.91
5	8.99	17.09	1.90	7.22	13.86	1.92
10	8.00	15.37	1.92	6.45	12.47	1.93
15	7.20	13.96	1.94	5.83	11.34	1.94
20	6.53	12.80	1.96	5.31	10.41	1.96
25	5.97	11.83	1.98	4.87	9.62	1.98

It should be remembered that these volumes of oxygen and nitrogen represent merely the maximum quantities of said gases that will be absorbed by said waters from the atmosphere after an indefinitely long exposure under the conditions of temperature and pressure named, and have nothing to do with the rate of such absorption, as for example, cubic centimeters per hour. The
2050 determinations are usually made shortly after the water has been vigorously agitated with the air, and all bubbles have been allowed to escape; the water is then said to be saturated with oxygen or nitrogen in solution.

For mixtures of fresh-water and sea-water, the quantities of oxygen and nitrogen at saturation will be proportional to the figures stated above, so that the said quantities will vary with the salinity. The question, however, relates only to the amount of oxygen that waters will hold in solution, and therefore any further consideration of nitrogen will be omitted. The volume of oxygen in cubic centimeters (V) measured as aforesaid, that will be absorbed by one litre of pure waters up to saturation at different temperatures (t) in degrees C., can also be expressed in simple algebraic form as follows:

(1) For distilled water: $V_1 = \frac{360}{t + 35}$;

(2) For pure sea-water: $V_2 = \frac{303}{t + 37}$.

To obtain the weight (W) of the oxygen thus dissolved, in terms of milligrams per litre, the said volume (V_1) and (V_2) are to be multiplied by 1.429, thereby obtaining

(3) Weight of oxygen absorbed by distilled water: $W_1 = \frac{514}{t + 35}$

(4) Weight of oxygen absorbed by sea water: $W_2 = \frac{433}{t + 37}$.

As already stated the figures given above are the determinations of Dittmar as published in "Challenger Reports," Physics and Chemistry, Vol. 1, p. 160. They were adopted by Adeney and Letts in their investigations described in Appendix VI of the Fifth Report of the Royal Commission on Sewage Disposal, London, 1908, pp. 58-59. A number of other determinations have been made since the publication of those by Dittmar, but they differ therefrom only in small degree. The most recent study of such figures was made by Messrs. G. C. and M. C. Whipple, and was published in "Journal of the American Chemical Society," Vol. 33, (1911), pp. 362-365, where the solubility of oxygen in
2051 a variety of mixtures of distilled water and sea-water is also given; their results are given in tabular form in terms of milligrams of oxygen dissolved, per litre of water, or parts by weight per million, and from them I have deduced the following algebraic formulas corresponding to those stated above:

(5) Weight of oxygen absorbed by distilled water: $W_1 = \frac{490}{t + 33.5}$

(6) Weight of oxygen absorbed by sea-water containing 20,000 parts of chlorine per million: $W_2 = \frac{432}{t + 38.2}$

A series of similar expressions for mixtures of distilled water and sea-water in different proportions was also deduced, but is here omitted. It may be added that when the weight of the absorbed or dissolved oxygen is given in milligrams, the corresponding volume in cubic centimeters, when at 0°C. and 760 millimeters borometric pressure, is found by multiplying said weight by 0.70.

In regard to the rate at which oxygen is absorbed by water from the air, the first extensive experiments seem to have been made by Dr. W. J. Dibdin about eighteen years ago with fresh-water of the River Thames, near London, and an account thereof is found in his book entitled "The Purification of Water and Sewage," 3rd. Ed. London, 1903, pp. 280-288. The water was completely de-aerated by boiling in a flask, which was then sealed and allowed to cool. After it had acquired the desired low temperature in the sealed flask, the water was transferred without agitation to open vessels in which it was exposed to the air for periods of time ranging from 1 hour to 96 hours. The ratio of water surface to depth in these vessels was unity, and the quantity of oxygen absorbed by the still water after different periods of exposure was determined by the usual gasometric method. Upwards of 150 such estimations were made, and the resulting figures were then plotted in diagram form with the duration of exposure in hours as abscissas, and the corresponding percentage of saturation of the water with oxygen as ordinates.

Through the series of points thus obtained a continuous
2052 curve was then drawn, which shows the average rate of absorption of oxygen by the water for each percentage degree of saturation.

The principal relations of this surve are exhibited in the following table, in which (x) denotes the number of hours of exposure of fully de-aerated water, and (y) is the resulting percentage of saturation of the water with dissolved or absorbed oxygen:

$x =$	1	3	5	7.5	10	20	30	40	50	60
$y =$	11	26	36	45	51	64	73	79	84	88

I found that the relation between (x) and (y) can be expressed very closely by the following two equations:

(7) For values of (x) from 1 to 12: $\frac{y = 86\,x}{x + 6.8}$

(8) For values of (x) from 12 to 60: $\frac{y = 166\sqrt{x}}{\sqrt{x} + 7}$

These expressions as well as the table, show that the rate at which oxygen is absorbed from the atmosphere by the water decreases as the degree of saturation, or period of exposure, increases. The figures under consideration refer to quiescent fresh water, and the volume of such water used in each experiment was probably not more than one gallon. Dibdin makes no reference to similar experiments with polluted water and sea-water, but applies his said results to the tidal waters of the lower Thames in computing the quantity of oxygen absorbed thereby from the air.

A number of other experiments on the rate at which oxygen is absorbed from the atmosphere by distilled water and sea-water were made by Dr. W. E. Adeney, and are recorded in Appendix VI of the Fifth Report of the Royal Commission on Sewage Disposal, London, 1908. The essential details and results of these determinations have been arranged by me in the following table:

Kind of water.	Condition of water service.	No. hours exposure.	Temperature. Degrees C.	Depth of sample.	Initial degree of saturation in per cent.	Average rate of absorption of Oxygen C. C. per litre per hour.
Sea Water	Quiescent	19	13.5°	16″	43.33	0.036
"	"	42	13.5°	16″	43.33	0.028
"	Gently Stirred	27	13.5°	16″	62.83	0.073
"	"	25	19.5°	2″	15.11	0.184
"	"	20	18.2°	2″	15.02	0.216
"	"	19	8.3°	42″	11.66	0.299
"	"	20	18.2°	50″	15.02	0.204
"	"	25	19.5°	60″	15.11	0.150
"	"	20	18.2°	70″	15.02	0.119
Distilled Water	"	12	13.0°	4″	10.40	0.391
"	"	12	13.0°	30″	10.40	0.103
"	"	19	8.3°	42″	9.03	0.258
"	"	12	13.0°	62″	10.40	0.051

It should be noted that these determinations of the quantity of oxygen absorbed were made only after the lapse of from 12 to 42 hours, and that the rates of absorption in cubic cenimeters per litre per hour given in the last column of the foregoing table, are the average rates found by me by dividing the total quantity of oxygen absorbed by the stated number of hours of exposure. The first three experiments were made in a cylindrical vessel 10 inches in diameter, filled to a depth of 18.25 inches; the remaining experiments were made in vertical tubes from 1 to 2 inches in diameter, and from 44 to 78 inches long. In some cases the tubes were in series, whereby the surplus air from the first was conducted into the second, and thence into the third table; but as the rates of absorption in the second and third tubes were much less than in the first, these figures have not been given in said table, as I did not consider them applicable to natural bodies of water.

On page 64 of said Appendix VI the following statements are made: "Circulation from the surface downward must be set up by thermal currents to some extent in all water exposed to daily and nightly variations of temperature, even in perfectly calm weather. But with such circulating currents the process of re-aeration of tidal waters of any decided depth must be a slow one in calm
2054 weather, and it is probably no quicker than in the experiments with long columns of water whose surfaces were kept continuously broken (by stirring or a jet of air). These show that the average rate of transmission * * * of oxygen from the air to a depth of 6 feet in not less than 0.08 cubic centimeters per litre per hour for sea-water, and 0.03 cubic centimeters per litre per hour for fresh-water."

With these two rates of absorption, Adeney next computes the rate in cubic centimeters per litre per hour at which oxygen is transmitted from the air through de-aerated tidal waters of different salinity to a depth of at least 6 feet in calm weather as follows, the proportion of sea-water (S) and fresh-water (F) being indicated by numerals and the volume of oxygen transmitted by (V) in cubic centimeters per litre per hour:

Proportions ..	All (S)	3(S) 1(F)	2(S) 1(F)	1(S) 1(F)	1(S) 2(F)	1(S) 3(F)	All (F)
V = ...	0.08	0.068	0.063	0.055	0.047	0.043	0.03

It should be noted that in comparing the results of Dibdin's Experiments with those of Adeney just cited, close attention must be given to the words used. The former refer to the entire volume of oxygen absorbed from the air in a given period of time by a surface stratum of water about 1.5 feet thick, whereas the latter relate to the rate of transmission of oxygen to a comparatively thin stratum of water about 6 feet below the surface. The rate of absorption at the surface of de-aerated fresh-water is much greater than at considerable depths. This is indicated in the preceding table which summarizes Adeney's results, where it appears that in the course

of 12 hours a sample of distilled water 4 inches below the surface absorbed oxygen at the average rate of 0.39 cubic centimeters per litre per hour, the initial degree of saturation being 10.4 per cent. and the temperature being 13°C. At this temperature the water becomes saturated with oxygen when one litre of it has dissolved or absorbed 7.50 cubic centimeters of said gas; hence the said initial degree saturation of 10.4 per cent. corresponds to a contents of 0.78 cubic centimeters of oxygen per litre, and at the end of 12 hours at the said rate of absorption the contents will be (4.68 +
2055 0.78) = 5.46 cubic centimeters of oxygen per litre, which corresponds to 73 per cent. saturation in a surface stratum 8 inches thick. On the other hand, Dibdin's experiments relate to fully de-aerated water and show that the said initial degree of saturation (10.4 per cent.) will be attained in about one hour, and that 12 hours afterward, or 13 hours after complete de-aeration, the degree of saturation attained will be 56.5 per cent. in a surface stratum about 1.5 feet thick. Considered in this manner, and remembering that Adeney's experiments with fresh-water are very few in number, the foregoing comparison is not very discordant.

Adeney's experiments with clean sea-water, as set forth in the aforesaid table, are very diversified in regard to depth and other conditions, so that a formula for the rate of absorption of oxygen by quiescent sea-water can be deduced from only the first two observations, in which the initial degree of saturation was 43.33 per cent., the temperature was 13.5°C, the periods of exposure were 19 and 42 hours, and samples taken at a depth of 16 inches below the surface. At this temperature one litre of sea-water is saturated with 6.00 cubic centimeters of dissolved oxygen, measured as aforesaid at standard temperature and pressure, so that 43.33 per cent. of saturation corresponds to an initial contents of 2.60 cubic centimeters per litre. After 19 and 42 hours exposure to the air the contents became respectively 3.28 and 3.77 cubic centimeters per litre, corresponding to 54.67 and 62.83 per cent. of saturation. By using a form of expression similar to that found for Dibdin's experiments with fresh-water, it will be found that the relation between the percentages (y) ofsaturation attained and the time of exposure in hours (x) after complete de-aeration is:

9. For clean and quiescent sea water: $$y = \frac{142.35\sqrt{x}}{\sqrt{} + 9.8}$$

and that the period of exposure from complete de-aeration to the said initial percentage of saturation (43.33 per cent.) is 18.4 hours. In applying this formula the value of (x) used must include this latter period when dealing with times of exposure after the
2056 initial percentage of saturation has been attained, while for times less than 18.4 hours the value of (x) is used directly. Thus for a period of $x_1 = 9$ hours after complete de-aeration, formula (9) gives $y_1 = 33.36$ per cent; and for a period of $x_2 = 36$ hours after complete de-aeration, or 17.6 hours after having attained the said initial saturation of 43.33 per cent., it gives $y_2 = 54.06$ per cent. In comparison with these figures, formula (7) de-

duced from Dibdin's experiments with fresh-water gives $y_1 = 48.99$ per cent. and formula (8) gives $y_2 = 76.62$ per cent. As the formulas are based on experimental results, it becomes useless to offer any explanations for difference between these computed values of (y) until the data have been verified by more elaborate physical investigations.

Adeney and Letts also made a number of other observations on the rate of absorption of oygen from the air by various kinds of polluted water, viz: exceptionally foul liquor from a septic tank, sedimented sewage from main sewers in Belfast and Dublin, and 20 per cent. mixture of these sedimented sewages with sea-water and distilled water. All of these experiments are fully described in the aforesaid Appendix VI of the Fifth Report of the Royal Commission on Sewage Disposal, London, 1908, on pp. 56-110, 433-438. From the numerical data there given I have deducted the following formulas, from which the volume (V) of oxygen in cubic centimeters absorbed from the air by one litre of said liquids and its contained organisms during (X) hours of exposure), can be computed with close approximation to the actual observations:

10)	For foul septic tank liquor:	$v=24\sqrt{x}+0.5x$
11).	For sedimented Belfast Sewage:	$v=15.6\sqrt{x}-0.45x$
12).	For sedimented Dublin Sewage:	$v=6.6\sqrt{x}-0.18x$
13)	For a 20 per cent. mixture of sedimented Belfast Sewage with sea-water	$v=2.2\sqrt{x}-0.01x$
14).	For a 20 per cent. mixture of sedimented Belfast Sewage with distilled water	$v=2.4\sqrt{x}-0.02x$
15).	For a 20 per cent. mixture of sedimented Dublin Sewage with sea-water	$v=3.0\sqrt{x}-0.10x$
16).	For a 20 per cent. mixture of sedimented Dublin Sewage with distilled water	$v=2.3\sqrt{x}-0.07x$

2057 In these experiments the observations were made at intervals of 24 hours during a week or more, and in deducing the formulas it was assumed that the liquids were fully de-aerated, or contained no dissolved ozygen, at the outset. This condition probably holds in formulas 10, 11 and 12, but it may not apply to the liquids represented by formulas 13 to 16 inclusive. It is however, stated explicitly in the tables that the figures denote the volumes of oxygen absorbed per 24 hours, and hence the consideration of the initial degree of saturation of the liquid with oxygen becomes eliminated in formulas 13 to 16.

The volume in cubic centimeters (V) of oxygen absorbed from the atmosphere during (x) = 24 hours after complete de-aeration by a litre of the different kinds of clean and polluted waters described in the foregoing, may now be compared as follows, a temperature of about 13°C. being assumed:

7.	Dibdin	for clean and quiescent fresh water	V =	5.1	cc. in 24 hrs.
9.	Adeney	for clean and quiescent sea-water	"	3.3	" " " "
10.	"	" septic tank liquor	"	113.0	" " " "
11.	"	" sedimented Belfast Sewage	"	51.5	" " " "
12.	"	" sedimented Dublin Sewage	"	26.5	" " " "
13.	"	" 20% Belfast Sewage with sea water	"	5.8	" " " "
14.	"	" 20% Belfast Sewage with distilled water	"	5.8	" " " "
15.	"	" 20% Dublin Sewage with sea-water	"	12.2	" " " "
16.	"	" 20% Dublin Sewage with distilled water	"	9.5	" " " "

From these figures it will be seen that when the water is polluted and fully de-aerated it absorbs more oxygen from the air than when it is unpolluted, also that the quantity of oxygen so absorbed varies greatly with the nature of the pollution. Adeney likewise experimented with a sample of polluted tidal water (l. c., p. 8) which had been kept for a week in a closed bottle and become completely de-aerated, as well as very offensive in odor. On exposing this liquid to the air, it absorbed oxygen in 24 hours at the rate of 57.5 cubic centimeters per litre, which is more than the absorption by Belfast Sewage. The highest absorption was by the foul septic tank liquor. It is to be regretted that the available data pertaining to the rate of absorption of oxygen by different liquids do not embrace complete chemical and biological analyses, whereby it might be possible to determine the relation between such rate and the degree of pollution as represented by some standard.

2058 The researches described in the foregoing show clearly that polluted waters have an avidity for oxygen, and that when mixed with clean and well-aerated waters, the quantity of dissolved oxygen in the latter will become reduced. The conclusion seems warranted that when organic matter decomposes in sea-water or brackish water, the first chemical change that occurs is chiefly the partial absorption of the oxygen dissolved in the water along with that which is re-absorbed from the air. A similar action will take place in Upper New York Bay if a large volume of polluted liquid, or effluent from sewage sedimentation tanks, is discharged at Robbins Reef, as proposed by the Passaic Valley Sewerage Commission.

Q. Have you studied the effects of the discharge of sewage into the sea and into tidal waters specially, and, if so, state with what results, and what your studies consisted of?

Mr. Riker: I object to that insofar as it relates to the discharge of sewage into the sea as irrelevant and immaterial, except possibly for the purpose of comparison.

The Commissioner: Note the objection.

A. I have given much study to the effects of the discharge of sewage into the sea and tidal waters and have observed such effects at numerous places. The localities that I have examined personally at different times are New York harbor, Upper East River, portions of Long Island Sound, Newark Bay, Raritan Bay, Boston, Philadelphia, Atlantic City, Baltimore, Washington, Norfolk, Va., San Francisco, Portland, Me., Portland, Ore., Seattle, Wash., Dublin harbor, Belfast harbor, Liverpool harbor, Glasgow, Edinburgh, Hull,

London, Dover, Southampton, Calais, Havre, Cherbourg, Amsterdam, Rotterdam, Antwerp, Hamburg, Bremen, Venice and Triest. In addition to these personal examinations, I have studied in numerous publications and official reports the results of the discharge of sewage into the harbors of Aberdeen, Belfast, Birkenhead, Crosby, Douglas, Dublin, Glasgow, Hull, Liverpool, London, Lytham, Plymouth, Portslade, Saltburn, Shotley, Southend, Southampton, Southwick and Sunderland, in Great Britain; Sydney, in
2059 Australia; Atlantic City, Baltimore, Boston, New York, Philadelphia, and various other places in the United States; Altona, Antwerp, Bremen, Christiania, Copenhagen, Hamburg, Havre, Helsingfors, Kiel, Marseilles, Memel, Naples, Odessa, Riga, Stettin, Swinemünde, Triest and Venice, on the European Continent.

In nearly all of these ports objectionable conditions of the water have resulted and caused improvements to be made in the treatment of the sewage and the mode of its discharge. In some cases the sewage was impounded in large tanks or reservoirs during flood tide; in other cases the sewage outlet pipes were extended into localities where owing to topographical peculiarities, the tidal currents were generally off-shore; and in the remaining cases it was deemed necessary to subject the sewage to a more or less extensive purification before discharging it into the sea or other tidal waters. In most of the cases the sewage was at least deprived of its coarser floating matters by screening.

All recent studies of the subject have demonstrated the importance of considering it from various points of view, such as the essentially physical ones of engineering and chemistry, the requirements of public hygiene, the economical or commercial effects upon the various kinds of sea-food for mankind, and the biological results upon the plankton in the tidal waters whereby the ultimate purification of the polluted water is accomplished. The neglect of any one of these considerations in cases where the amount of pollution is large, is likely to result in unsatisfactory conditions and expensive alterations or reconstruction work; and the reason for this probability is that scientific investigations of some of the important factors involved in these considerations have only been made to small extent. Many sea-port cities have increased greatly in population, industries and commerce within the past two or three decades, and the evils of the over-pollution of their harbor waters have been recognized only in recent years. The methods of investigating the contamination of fresh-water have not been found to be free from serious error when applied to salty waters,
2060 and the organisms by which the self-purification of salt and brackish waters is effected are now found to be different in many respects from those of fresh-water. A variety of new problems has therefore appeared and are still in process of solution.

The methods of discharging sewage into the sea and tidal waters are as various as those which relate to inland water, although up to the present time the simplest ones have most commonly been adopted. The opinion has hitherto prevailed that the sea with its

enormous volume, must necessarily be a much more suitable recipient for sewage than relatively small bodies of fresh water, but experience has proved that in many cases only a comparatively small fraction of the tidal volume in the locality is available for purification purposes, and that numerous objections arise to discharging sewage into tidal waters which do not appear with inland waters. Much will depend on the intensity and direction of the predominant tidal currents and the location of the sewage outlet in regard to the rapid dispersion of the putrescible organic matter. Frequently such matters are brought back by the flood tide without extensive dispersion, and are then reinforced by the newly-discharged substances, so that the pollution becomes manifolded by the tidal oscillations. In other cases an advantage is sought by carrying the outlet pipes into deep water at a considerable distance from *from* the shore, in the hope of discharging the sewage into relatively swift and swirling currents which will cause it to intermingle quickly with a large volume of tidal water; but we then have the great difficulty of locating and studying such currents, as well as the tendency of the sewage to rise to the surface by reason of its lower specific gravity and higher temperature.

The suspended solid matters in the sewage are often a source of serious injury to harbor waters, owing to their tendency to settle more rapidly in salt-water than in fresh-water. Unless they are carried far away to sea by the ebb currents, they will form a deposit of slimy mud on the bottom, and when the discharge is continuous the entire bottom will become thus covered, as in the case of New York Harbor. These deposits undergo bacterial
2061 decomposition, during which the amount of oxygen necessary for the process will be abstracted from the quantity of this gas that is dissolved in the water, and to this extent it will interfere with the more rapid oxidation of the dissolved organic matter. Experiments made by Adeney and Letts with samples of polluted mud from Belfast Lough and the Thames Estuary, (reported in Appendix VI of the Fifth Report of the Royal Commission on Sewage Disposal, London, 1908, pp. 129-134) showed that when from 10 to 12 grams of such wet mud were brought in contact with fully aerated fresh-water in tightly stoppered flasks containing one litre of water, from 42.5 to 77.7 per cent. of the oxygen dissolved in said water was absorbed by the mud in 3 hours, from 61.5 to 94.9 per cent. in 6.5 hours, and from 88.7 to 98.3 per cent in 10 hours. From these figures the detrimental effect of putrescent mud upon the quality of sewage-polluted harbor waters becomes very apparent.

The decomposition or fermentation of these deposits is frequently also attended with the development of disagreeable odors and gases. Prominent among the latter is sulphuretted hydrogen, due to the reduction or breaking down of sulphates and sulphides, but the peculiarly fetid smell often observed is caused by other substances of organic nature. Both sea-water and land-water, as well as sewage, contain an abundance of alkaline and earthy sulphates which are gradually reduced to sulphides by contact with carbonaceous sub-

stances and the action of a variety of living marine organisms. The resulting alkaline sulphides then undergo double decomposition with any oxides of iron or manganese that are present in the mud, whereby sulphides of iron and manganese are formed; and when these latter sulphides are exposed to oxygenated sea-water on the surface of the mud, they are again quickly oxidized with the evolution of sulphuretted hydrogen. Bacteriological researches have disclosed the existence of at least two specific anaerobic micro-organisms (Spirillum desulphuricans and Microspira estuarii) which are always found in sewage sludge and which effect a powerful reduction of sulphates to sulphides without evolving hydrogen; but it was also found that the presence of organic matter is neces-
2062 sary for the action of these organisms, and hence it is presumed that the oxidation of this matter with production of carbon-dioxide furnishes the energy necessary for said chemical reduction.

Sulphuretted hydrogen is also formed directly by the bacterial decomposition of albuminous bodies, and many species of micro-organisms are able to generate this gas from ordinary culture media. Ferrous sulphide, which is very plentiful in foul mud-deposits, likewise appears to be a prolific source of the sulphuretted hydrogen emanating from such mud, as it is readily decomposed by the carbon-dioxide or carbonic acid resulting from the oxidation of organic compounds. The action of ferrous sulphide in mud along with its power to destroy nitrates and evolve ammonia, is fully described in the aforesaid Appendix VI of the Fifth Report of the Royal Commission on Sewage Disposal, London, 1908, pp. 122-126. Another important feature of such deposit is the fact that much finely divided matter is carried up to the surface of the water by the ascending bubbles of gas formed as above described. On the escape of the gas into the atmosphere, this matter remains suspended in the water for a long time and renders the same turbid. The ascent of the gas in quiescent water also induces slight vertical currents, which cause some of the soluble products of putrefaction of the mud to be mingled with the water and abstract dissolved oxygen therefrom; and if the tidal currents have a swirling or eddying motion, it is obvious that these actions will be increased.

The discharge of sewage into tidal waters may also result in the development of a profuse growth of certain sea-weeds, which originate on mud deposits and afterwards detach themselves to maintain a free existence in the polluted water alone. The most notorious plant of this kind is Ulva latissima, or "sea-lettuce" which began to multiply with great rapidity some years ago in Belfast Lough, and now drifts ashore in enormous quantity where its decomposition causes a serious nuisance in warm weather. Similar results from sea-weeds are observed in other places, and it has been found that after the water reaches a certain stage of sewage pollution,
2063 an aquatic vegetation of a different kind than prevailed formerly in the locality will appear and grow extensively. Concerning the evolution of such new plants, little is known, but it is

likely that their appearance is due to accidental transportation from another place by vessels, drift-wood and storm currents.

Of the pollution of the shores by floating and suspended sewage matters, whose decomposition gives rise to offensive odors and whose presence in the water is repulsive, little need be said except to refer to the resulting depreciation of the value of the marginal lands. Similarly with regard to the contamination of the water by the various sewage bacteria, in consequence of which bathing places are ruined and plantations of shellfish are rendered dangerous. It will suffice to mention here that pathogenic germs can exist in salt water for considerable periods of time, and that diseases like typhoid fever and cholera have often been caused by eating oysters, mussels and other shellfish taken from infected waters. These dangers are now fully recognised in all civilized countries, and there is a growing demand for stringent governmental inspection and control of the sources of such food.

A good reason for efficient guards against the infection of tidal waters and the distribution of diseases therefrom, is the fact that much fewer saprophytic micro-organisms are present in brackish and sea-water than in fresh-water, and that continuous currents in the same direction, as in a river, are of rare occurrence. The frequent variations in salinity in the neighborhood of rivers are also prejudicial to the establishment of an effective scavenging plankton. It may likewise be added that our knowledge of the chemical and biological processes which take place in the self-purification of polluted coastal waters is still inadequate to inspire much confidence in palliative measures, and that the said dangers to the public health can be eliminated only by far-reaching and costly methods of sewage treatment.

Concerning the economical or commercial consideration of the subject, much might be said in regard to the value of the
2064 shellfish and other sea-food destroyed or driven to other more attractive localities by the discharge of large volumes of sewage. It is known that oysters are killed by the sulphuretted hydrogen evolved from foul mud-deposits, or when masses of such decomposing mud are transported to their vicinity by currents induced by severe storms; hence in artificial plantations of oysters, much expense must be incurred to maintain the cleanliness of the water and beds. If sewage reaches these beds, the oysters will gradually disappear and be replaced by mussels or other less valuable molluscs. A notable case of this kind occurred at Schastopol, in consequence of the construction of sewers and the discharge of the sewage near a place where oysters were formerly very abundant.

Many species of edible crustacea, such as lobsters and crabs also seem to be injured by sewage, the effects being particularly noticeable when the discharge occurs near their breeding places. In his recent report on the pollution of the northern part of the Adriatic Sea, Steuer states that the number of lobster captured in those waters has reduced greatly during the past few years, and that the supply must now be obtained from the Dalmatian Coast. A similar reduction has likewise occurred in the catch of other crustacea

and squids in the waters mentioned. Several species of valuable fish have also disappeared therefrom, and it was observed that when the pollution from a distillery in a certain locality on the shore was stopped and the water again became clean, the fish returned. Similar statements are found in the reports of the fishery authorities of all nations, so that further citations seem unnecessary.

With respect to the biological results of sewage pollution upon the plankton in tidal waters, reference is made to my answers to a previous question concerning the plankton of fresh and brackish waters, as well as to a number of allusions thereto made above. In general it may be said that the majority of the fresh-water organisms die when carried into brackish water or sea-water, and that Nature has provided a distinct class of organisms which are adapted to flourish in salty waters and accomplish the work of puri-
2065 fication. A number of the fresh-water bacteria of putrefaction, however, continue to live and perform their functions in tidal waters, but they are usually confined to the coastal region which is affected by pollution from the land. According to chemical analysis the open sea is free from dissolved nitrogenous matter of organic origin, which constitutes the nourishment of the vegetable component of the coastal plankton, and hence it contains comparatively few bacteria and algæ. In polluted sea-water the number of bacteria depends essentially on the number discharged therein by fresh-water and sewage, and hence the salinity of the water is an important factor.

The character of the bacteria and algæ found in the water is an index of the degree of its pollution, and if they are predominantly of the saprophytic varieties, it is safe to infer that the contamination is extensive. Some of the algæ, like Ulva and Enteromorpha, are known to be facultative saprophytes, as proved by the experiences at Belfast, Helsingfors, Triest, Rovigno and Sebastopol. In regard to the relation of marine fauna to pollution our knowledge is yet rather limited, but it may be assumed that it is similar to that of the fresh-water fauna. Numerous mollusks, sponges, byrozoa, crustacea and fishes disappear when the sea-water is strongly contaminated. A few attempts have been made to formulate the groups of vegetable and animal organisms that predominate in tidal waters of different degrees of pollution, but the task seems to be exceedingly difficult owing to variations in behavior in different localities. It is evident therefore that many further investigations must be carried out before a satisfactory system of classification can be established, and meanwhile it will be prudent to err on the safe side by requiring that the sewage of our large coastal cities shall at least have the greater part of its polluting matter removed before discharging it into tidal waters.

This requirement, however, must be coupled with the important condition that the point of discharge shall be carefully se-
2066 lected, so as not to cause objectionable results in other neighboring localities. A thorough study of the prevalent currents at all stages of tide is necessary at the contemplated outlet,

and the effect of winds on the surface currents must likewise be determined by various kinds of floats, because sewage is lighter than salt water and remains on the surface thereof until finally dispersed in calm weather by the comparatively slow process of diffusion or intermixture, whereby the upper strata acquire the same salinity as the lower ones. This tendency of sewage or fresh-water to float on the surface of salty waters is a well-known fact, and it is manifested even when the discharge takes place at considerable depths below the surface of sea-water. Thus, although the outlets of the South Mertopolitan Sewer near Peddock's Island in Boston Harbor, and the Rhondda Valley sewer in Wales, are at depths of from 30 to 40 feet below the surface of the sea, the turbid sewage always rises to the top and spreads out in fields of large size. It has also been observed that at the mouth of the River Congo, the fresh-water flows out over the salt-water in a sheet having a thickness of only a few feet, and affects the salinity in an area of about 38,600 square miles (Schott, "Physische Meereskunde," 1903, p. 50).

Considerable attention has recently been given to the sewage sludge fields forming at the three large sewage outlets in Boston harbor, viz: at Moon Island, Deer Island and Peddock's Island, and also to those forming in New York harbor and Jamaica Bay. As this subject is fully discussed in the testimony given in these proceedings, by Mr. John P. Fox, on June 5, 6 and 7, 1912, further reference thereto will here be omitted, excepting to remark that a field of comparatively colorless and bacteria-laden effluent from a sewage treatment plant, will form on the surface of sea-water as readily and extensively as unclarified sewage.

The character and composition of the sewage is another important factor in the case of marine outlets. The results of many analyses show that from 50 to 70 per cent of the total solid matters
2067 left after evaporating the water of the sewage, was in solution, either true or colloidal; also that the same figures apply to the proportion of organic matter in the total solids, and that the greater part of this organic matter was in colloidal solution and capable of undergoing oxidation or putrefaction. In the sewage of Manchester, England, about 60 per cent. of the oxidizable matter and 76 per cent. of the albuminoid nitrogen were found in the colloidal state; and in the sewage of Hampton, England, fully 50 per cent. of the organic matter in solution was colloidal. It may be stated in this connection that the examination of sewage in respect to colloids is of quite recent date, and that the consideration of such substances is hitherto very limited in text-books and reports on sewage disposal. Their plentiful appearance in many effluents from disposal works, however, together with their putrescibility, entitle them to receive the most careful attention.

Where chemicals are not used for coagulating and precipitating the colloids and suspended solids in sewage, and for disinfecting the resulting effluents, it is plain that most of the bacteria and dissolved organic matters will pass with the effluent into the recipient body of water; and in the case of sea-water the effluent will form a field thereon, as already mentioned. These more or less invisible

fields are obviously dangerous to the public health, and should not be allowed to form in localities where they can be transported by tidal currents and winds to bathing beaches and plantations of shellfish. In selecting the point of discharge, it is therefore necessary to study closely all the physical peculiarities of the recipient waters, and to make the best use of all the natural agencies of purification that are available.

Adjourned to Monday, June 17th, 1912, at 10:30 A. M.

2068 Supreme Court of the United States, October Term, 1911.

THE PEOPLE OF THE STATE OF NEW YORK, Complainants,
against
STATE OF NEW JERSEY and PASSAIC VALLEY SEWERAGE COMMISSIONERS, Defendants.

CORPORATION COUNSEL'S OFFICE, NEW YORK CITY,
June 17th, 1912, 10:30 a. m.

Present: James D. Maher, Esq., Commissioner.

Appearances:

Dr. William J. O'Sullivan, Special Counsel for the People of the State of New York, Complainants,
Adrian Riker, Esq., of Counsel for the Passaic Valley Sewerage Commission, Defendants.

Met pursuant to adjournment.

HARRISON P. EDDY, a witness called on behalf of Complainants, being first duly sworn, testified as follows:

Direct examination by Mr. O'Sullivan:

Q. What is your full name?
A. Harrison P. Eddy.
Q. And where do you reside?
A. In Worcester, Massachusetts.
Q. Where is your place of business?
A. I have an office in Boston and another in Chicago.
Q. With Assistants in both?
A. Yes, sir.
Q. What is your profession, Mr. Eddy?
A. Consulting Engineer, making a specialty of water and sewerage work.
Q. When did you begin your experience in engineering?
A. I started as a boy in the city engineer's office at Worcester, working summers. Went to Worcester Polytechnic Institute, graduating in 1891.
Q. In what department?

A. In the Department of Chemistry.

2069 Q. With what degree?

A. Bachelor of Science.

Q. Did you make any specialty during your studies?

A. I made a special study during my course there on the purification of sewage.

Q. Did that include sewage disposal schemes in general?

A. Yes, sir, but primarily the purification by chemical precipitation.

Q. Did you take that as a subject of a thesis on graduation.?

A. I did.

Q. Now, in June, 1891, where were you employed?

A. In June 1891, immediately after graduation, I entered the employ of the Worcester Sewer Department, as chemist, to the purification works. I occupied that position for the period of about two months, after which I took the position of Superintendent of those works, which position I occupied for a period slightly over a year and two months when I was elected to the position of Superintendent of the entire Sewer Department. I held that position——

Q. One moment. You were Superintendent of the Sewage Purification Works of Worcester, Massachusetts, up until November 1892; is that right?

A. Yes, sir.

Q. Continue from there?

A. From November 1892, when I was elected Superintendent of the Sewer Department, I had charge of that department until the last of April, 1907, a period of nearly fifteen years. During that time the sewage purification works at Worcester were very materially enlarged. At the time I took charge of the plant it was capable of purifying about three million gallons of sewage per day. In 1893, I enlarged the plant to a capacity of about 15 million gallons per day, the process in use being that known as chemical precipitation. In 1897 I added the sludge pressing plant.

Q. Did you design any of the machinery?

A. I designed all of the machinery practically that was used.

2070 Q. And how about the storage basins?

A. The storage basins, the filter beds and all in connection with the plant.

Q. How much of an improvement, as far as expense would be concerned, would that be?

A. That particular improvement I think costs about $100,000.

Q. Based on your recommendation and your designs?

A. It is wholly.

Q. Now, starting from 1897?

A. About the same time I recommend that the method of purification of sewage by intermittent sand filtration be added as supplementary to the chemical precipitation then in use, and began the construction of sand filters.

Q. Occupying about what space?

A. At the end of my term of office in 1907, we had about 45

acres of sand filters, costing, in round numbers, I should say, $250,000. During this period from 1892 until 1907, I had charge of the construction——

Q. Did you say 1902 or 1892?

A. 1892 until 1907, I had entire charge of the construction of the sewer system of the City, which included the natural extensions, and in addition involved the separation of the sewage from storm water by means of new sewers, covering a large proportion of the area of the city, and building an intercepting sewer system to divert the sewage from brook water, and thus reduce the quantity which it was necessary to treat at the sewage purification work. The cost of that——

Q. One moment. Did you build any new line of sewer, and if so what was the length or extent of them?

A. We were building new lines of sewers continuously. The largest sewer was a combined sewer receiving both storm water and sewage, which was about 18 feet wide and 13 feet high in cross section. This sewer was about 3 miles long, although the portion which I built, I think, was only about one third of that.

2071 The intercepting sewers which I built between 1897 and 1901, were, all told, about 7 miles in length, the natural extensions of the system and the duplication required by the separation of the sewage from the storm water involving the construction, probably, of about 100 miles of sewers.

Q. At an approximate cost of about how much?

A. An approximate cost of between one and two million dollars. I should say that probably the total cost of the sewerage work which I did in Worcester is not far from two million dollars.

Q. Now, during your term as Superintendent, did you conduct an experiment station and laboratory for research in connection with the purification of sewage?

A. I equipped the laboratory while I was still at Worcester Polytechnic Institute in 1890 and 1891, and from that time until I severed my connection with the City of Worcester in 1907, it constituted an experiment station on the purification of sewage and on allied problems.

Q. What studies did you engage in, what schemes, enumerate them?

A. I studied the effect of the dilution of sewage; the process of chemical precipitation, intermittent filtration through sand; purification by means of contact filters.

Q. What are they commonly called?

A. Contact filters.

Q. Or contact beds?

A. Contact beds, or bacterial beds. I also studied the method of purification by means of trickling filters, known also as sprinkling filters or percolating beds. We made a continuous series of experiments on the disposal of sludge by various means and during this period of time conducted continuous studies of the work effected by the purification plant; the proportion of the organic matter removed by the several processes in use, and also studies of the river

to note the effect of the discharge of the sewage, or the effluents into it.

2072 Q. Did you conduct any line of experiments in that experiment station on the septic treatment that was coming into vogue about that time?

A. We did, very extensive experiments on a large scale. That is a relatively large scale, where we actually treated by that process about 300,000 gallons of sewage per day.

Q. By what means?

A. By means of the septic tank, passing it out and to our large settling basins.

Q. State what you mean when you employ that term "septic tank."?

A. The "septic tank" as I have used that term, means a large basin into which the sewage continuously flows, and through passing which *it* flows out at the further end at substantially the same rate at which it enters, the solid matter being deposited in the basin and forming a layer of thick mud, commonly known as sludge, on the bottom of the basin. This process is so controlled as to give ample opportunity for the organisms in the sewage and in the sludge, which accumulates at the bottom of the basin, to act upon the organic matter, transforming it from the more complex to the simpler components. It is accompanied by the ebullition of relatively large quantities of gas as a decomposition product. The sewage becomes black and putrid and usually has an offensive odor.

Q. Now, Mr. Eddy, coming to May 1907. Did you sever your connection with the City of Worcester?

A. I did, yes sir.

Q. What did you do then?

A. I formed a joint partnership with Leonard Metcalf.

Q. Under the firm name of?

A. Under the firm name of Metcalf and Eddy.

Q. Is that in existence today?

A. That firm is in existence today.

Q. And has it been so continuously since its formation in May, 1907.

A. Yes, sir.

2073 Q. Now, what have you devoted your energies to since the formation of that partnership in May 1907?

A. At the time the partnership was formed, I was acting as Consulting Engineer for the City of Norwalk, Massachusetts, where a sedimentation tank and intermittent sand filters were built. At the same time I was acting as Consulting Engineer for the City of Louisville, Kentucky, where in collaboration with Mr. Grey and Mr. Breed, both engineers, I designed a system of sewers. Beginning in 1907, I acted as Consulting Engineer for the construction of that system of sewers, Mr. Breed, formerly mentioned, being the Chief Engineer. This work involved the expenditure of about four million dollars. At about that same time our firm was employed by the Boston Finance Commission to make studies of the

Boston Water and Sewer Departments. Upon that work we made about 65 reports to the Finance Commission, which have subsequently been printed in a volume of some twelve or fifteen hundred pages.

Prior to that time, I made a special study of the Boston Fenway Sewers at the request of the Acting Mayor of the City of Boston. I made a special investigation of the sewage filters at Pittsburg, Massachusetts. Those were sand filters for the purification of sewage.

Q. Did you have any others about that time, Westboro, Pittsfield, Marlboro, Gloversville?

A. Yes sir, I acted as Consulting Engineer to the Constructing Engineer as well for the City of Marlboro in remodeling its sand and filtration plant, building new storage basins, and 10 or 15 acres of sand filters, also for the City of Gloversville, New York, where an experiment station was operated under my direction for a period of somewhat over one year. At this experiment station various methods of purification of the sewage were tried experimentally, and as a result of this work, I designed the plant now nearly com-
2074 pleted in Gloversville for the purification of the sewage, which plant consists of vertical sedimentation stations, sprinkling or trickling filters, secondary sedimentation basins and sand filters, sludge beds are also provided for the disposal of the sludge at Milwaukee.

Q. One moment. What did you have to do at Westboro?

A. At Westboro, Massachusetts, I was engaged by the Town to assist in defending a certain litigation against the Town resulting out of the alleged imperfect operation of the sewage filtration beds.

Q. Did you mention anything about Pittsfield, Massachusetts?

A. I did, yes sir.

Q. Did you have any business conferences or consultations in your professional capacity for any of the municipalities in the State of New Jersey about that time?

A. I did, recently, make a report to the State Board of Health of New Jersey, relative to the location of a trickling filter plant for the purification of sewage in the Township of North Plainfield. Prior to that time I made a report for the cities and towns of East Orange, Montclair, Glen Ridge and Bloomfield, and I think one other town the name of which I have now forgotten.

Q. Orange itself?

A. I think Orange itself was included. In this report I outlined a method by means of which the sewage of that community could be purified before it was discharged into any natural stream of water.

Q. And as a substitute for entering into the Passaic Valley Sewerage project?

A. It might be used as such, although I did not consider the Passaic Valley Sewerage project. I was not asked to consider it in any way in that connection.

Q. Have you had any professional relations with the City of Milwaukee, Wisconsin?

A. I have. In 1909, I was engaged as one of a Board of Consult-

ing Engineers, consisting of John W. Alvord, of Chicago, George C. Whipple, of New York and myself to make a study of the
2075 sewerage and sewage disposal problems of the City of Milwaukee. These studies involved also the study of the water supply of the City of Milwaukee and in 1911, this Board made its report recommending a system of intercepting sewers for the collection of sewage, the erection of settling basins for the sedimentation of the sewage, and pumping plant and trickling filters, which discharge into the lake.

Q. Now, in the years 1907 and 1908 were you retained to make any investigations of the water and sewer departments of Boston itself?

A. Yes sir, for the Boston Finance Commission that I have already alluded to.

Q. Prior to that in the year 1906, did you make any special investigations for the City of Boston?

A. I did. I made a special study of the Fenway contracts for the Acting Mayor.

Q. And that involved an expenditure on the sewer system which you were investigating of how much?

A. About one million and a quarter dollars.

Q. What did the work *as* Gloversville, New York, involve?

A. As to cost?

Q. No, what scheme, what matters were you called upon to investigate?

A. The investigation covers studies of the character of the sewage and the various methods available for its purification.

Q. Did it involve the building and operation of an experiment station there?

A. Yes, sir, for a period of somewhat over one year.

Q. Was there anything peculiar about the sewage at Gloversville?

A. The sewage at Gloversville is very strongly influenced by the tannery sewage. While there are but 20,000 persons in the City, the sewage or wastes from about 20 to 20 tanneries, is discharged into the main sewer, which makes it particularly difficult to purify by biological methods.

2076 Q. Why?

A. On account of the disinfecting action of the chemical wastes from the tanneries.

Q. You mean the trade wastes?

A. The trade wastes; yes sir.

Q. Now, in that same year, 1906, were you engaged in conjunction with any other engineer in designing a system of sewerage for the City of Louisville, Kentucky?

A. Yes, sir, Messrs. Gray and Breed.

Q. About how long a system of sewers; what length would that be?

A. I think the length of sewers designed was about 60 miles, and that system is now practically completed, having been built under my direction, as Consulting Engineer.

Q. At a cost of about how much?

A. Four million dollars.

Q. Let us get a little nearer to the present time. In the year 1910 I think you have stated that you had made investigations of the water works of Milwaukee; what have you done in the year 1911 as consulting engineer?

A. During 1911 I have acted as Consulting Engineer for the City of Pittsburg, Massachusetts, where we have already built an intercepting sewer to collect the sewage of the city and convey it to the site of the proposed sewerage purification works. We have designed tanks for the sedimentation of the sewage, these tanks being known as the Imhoff or Emscher type of tank, together with trickling filters, followed by secondary sedimentation tanks, and also sand filters a part of which will be used for the purification of the raw sewage, and a part for the further purification of the effluent from the trickling filters.

Q. In 1911 what I was most particularly anxious to inquire relative to, Mr. Eddy, were you retained in any capacity in your profession by the Metropolitan Sewerage Commission of this State?

A. Yes, sir; in the summer of 1911, I was retained by the Metropolitan Sewerage Commission to examine the condition of New York Harbor and make a report upon a standard of cleanness,
2077 which I thought it was practicable and wise to adopt for this harbor, and made out a report.

Q. Now, at the present time will you state some of the municipalities that have retained you in your capacity as Consulting Engineer.

—. One of the most recent engagements was for the City of Pittsburgh, Pennsylvania, where Messrs. Hazen and Whipple of New York had made very extensive studies upon the sewerage and sewage disposal problems of that City and community. I was engaged in collaboration with Mr. Frederick P. Stearns of Boston, Massachusetts, to review their studies and to make a supplementary report covering the general problem. I have recently been retained by the City of Cincinnati, Ohio, to act as Consulting Engineer and to supervise the new sewerage investigations, which will require the making of a topographical map covering about 100 square miles of the city and neighboring territory; also an underground survey and maps covering 350 miles of sewers; the gas pipes, water pipes, telephone, electric light, telegraph conduits, and the street railway system. Study of the general problem of purification of the sewage of the City and the problem of improving by diverting the sewage and washings through such other means as may be necessary certain open creeks which run through the city and are now very offensive.

The work at Pittsfield, Massachusetts, is still in hand. We are acting as Consulting Engineers on the operation filter at Marlboro, Massachusetts, together with the various smaller works at industrial establishments and small cities.

Q. Are you still retained as Consulting Engineer to the Disposal Commission of Pittsfield, Massachusetts?

A. Yes sir.

Q. Are you still retained by the City of Louisville, Kentucky, in any capacity?

A. Yes sir, as Consulting Engineer.

Q. Are you still retained by the City of Gloversville, New York?

A. Yes, sir.

Q. Are you actually engaged now or have you been dur-
2078 ing this month of June on any consulting work in the West?

A. I have returned from a trip to Cincinnati and Louisville, Kentucky, where I have been in consultation on sewage work at Louisville, and sewage work at Cincinnati.

Q. Do you belong to any of the recognized societies or associations of Civil Engineers?

A. I am a member of the Boston Society of Civil Engineers; a member of the American Society of Civil Engineers; a member of the New England Water Works Association; the British Society of Chemical Industry; the American Chemical Society.

Q. How about the Public Health Association?

A. The American Public Health Association, the American Society of Testing Materials.

Q. How about the International Society for Testing Materials?

A. I am a member of that also.

Q. Have you spent any time abroad at all completing the studies that you have undertaken in this country?

A. I made a tour of the sewage purification works of England in 1894 and in 1909, I spent several months in England, Scotland, France and Germany in a similar study of the sewage purification works.

Mr. O'Sullivan: I am going to offer this witness as an expert and will later call upon him for his testimony, opinion, evidence based upon his testimony and I think I have now qualified him as an expert. If there is any doubt about it, you may ask him questions on this point.

Mr. Riker: You could have qualified him without going through his personal experience to such a large extent. I know Mr. Eddy and he has advertised his work so extensively. I know about him.

Q. Have you any familiarity with the condition of the harbor waters of New York Harbor, and if so, state what familiarity
2079 you have, and how you obtained such knowledge?

A. Have you been familiar with the harbor, in a general way, for many years having traversed its waters in boats of various kinds and having examined it by inspection from various piers and parks.

July 13, 1911 made a tour of inspection of portion of Upper Bay and East River. Examined particularly waters in vicinity of outlet tunnel from Gowanus Canal, Wallabout Bay, Newtown Creek, East River to Classon Point, Harlem River from Hell Gate to Willis Avenue Bridge.

July or August made inspection of Bay, Upper Bay, Narrows, portion of Lower Bay and Jamaica Bay, paving particular attention to character of water in Upper Bay on both east and west

sides; the Narrows, the Lower Bay just off Coney Island, Jamaica Bay and the Atlantic Ocean along Rockaway Beach.

September 6, 1911, view of Passaic River from Newark Bay near Lehigh Valley Railroad Bridge to Great Falls at Paterson.

On October 19, 1911, made inspection of lower Hudson and East Rivers and Harlem River as far as Putnam Railroad Bridge.

Have examined by observation, waters about Battery at numerous times during 1911.

Q. You mentioned that in July 1911 that you made a tour of inspection of some of the creeks; will you name those?

A. The Gowanus Canal, Wallabout Bay, Newtown Creek, aside from the principal arms of the harbor, were the points that I gave most attention to.

Q. And in September I think you said you made another tour of the Passaic River from Newark Bay to the Lehigh Valley Railroad Bridge?

A. Near the Lehigh Valley Bridge to Great Falls at Paterson.

Q. Have you devoted any study to the Passaic Valley
2080 Sewerage project itself?

A. I have. On numerous occasions I have familiarized myself with it in a general way when the early reports were published and from the engineering literature at the time, so that I have been in a general way familiar with it, for a good many years. About two years ago when I made a report for the City of East Orange, I became quite familiar with the Passaic River, but did not give particular attention, or any attention in fact, to the Passaic Valley project, as a project. Later, last year, and some months ago, I gave more particular attention to the Passaic Valley project itself.

Q. As finally adopted?

A. As I understand it to have been finally adopted, yes sir.

Q. Now, as you understand it from that study, what does it consist in?

A. The Passaic Valley project, as I understand it, consists essentially of a main trunk sewer running from the Newark Meadows up the Valley substantially parallel with the Passaic River to the City of Paterson, with such branches and connections as may be necessary to collect the sewage of the various muncipalities to be served, beginning with Newark and ending, I believe, with Paterson. Upon the Newark Meadows at the lower end of the intercepting sewer, there will be a pumping station for lifting the sewage, which will be delivered at that point at a very low elevation into settling basins.

Mr. Riker: One moment. I want to put on the record an objection to the testimony as to this project by guess. If this witness is to be called upon as an expert to testify upon a hypothesis involving the construction of the Passaic Valley Sewer and plant, that plant should be proved in a legal way before this witness can give testimony on it, and his evidence being hearsay is not admissible.

The Commissioner: Note the objection.

Q. Proceed, Mr. Eddy?

A. Prior to passing through the basins there will be a coarse screen and also at the basins there will be a somewhat finer
2081 second screen.

At the Newark Meadows the sewage will be screened, passed through grit chambers and then pumped to sedimentation basins. After passing through these basins, where it is intended to remove from the sewage a portion of the suspended matter, the sewage will enter a tunnel under Newark Bay, Bayonne and New York Upper Bay to a point near Robbins Reef lighthouse. At this point it is intended to discharge the sewage into a battery of pipes provided with orifices, through which it will be discharged into the waters of the Bay.

Q. From your studies have you made any sketch or plan showing in a general way the location of the portion of the municipalities and the trunk sewer pumping station, tunnel and outlet?

A. I have, yes sir.

Q. Whose work is that?

A. It is copied from the report of the Passaic Valley Sewerage Commission.

Q. Let me see that?

(Witness produces blue print.)

Q. Where was this chart or map prepared Mr. Eddy?

A. At my office, at Boston.

Q. Under whose directions?

A. Under my direction.

Mr. O'Sullivan: I offer this chart or map entitled "Plan and profile of proposed Passaic Valley District Sewer and Connections." I offer it in evidence and ask that it be marked Complainants' Exhibit No. 127 in evidence.

Cross-examination by Mr. Riker:

Q. Upon what did you say this sketch is based?

A. It is taken from the map in the report of the Passaic Valley Sewerage Commission. The printed report, I think the date is 1908.

Q. 1908?

A. I think so.

Q. Well, do you know whether that represents the present plan of the Passaic Valley Sewerage Commissioners?

A. I do not.

Q. How does it happen that you do not know?

A. I have no means of knowing.

2082 Q. Have you made any application to find out?

A. I have not.

Q. I see this sketch is dated February 5, 1912, is that your figure?

A. Yes, sir.

Q. That has nothing to do with the Passaic Valley Sewerage Commissioners?

A. Not that I know of.

Q. Is this a copy of the map that was attached to the report that you have mentioned?

A. It is, yes.

Q. It is a copy?

A. Yes, sir.

Q. Why did not you produce the original?

A. Because it is too cumbersome.

Mr. Riker: I object to the offer on the ground that it appears to be an unverified, unofficial copy of a report which is over four years old, and does not appear to represent now the plan of the Passaic Valley Sewerage Commissioners.

Mr. O'Sullivan: Counsel for Complainants serves a demand and notice upon Counsel for Defendants to produce the original of that map for the purpose of offering it as an exhibit in its case on behalf of the Complainants.

The Commissioner: Note the objection.

Mr. Riker: I have had no notice to produce it at this hearing and I have not it with me and consequently cannot now produce it.

The Commissioner: Note the objection.

Received and marked Complainants' Exhibit No. 127.

Marked Complainants' Exhibit No. 127.

Direct examination by Mr. O'Sullivan (resumed):

Q. In considering this Passaic Valley Trunk Sewer project, did you take into consideration, estimates of population to be served by the Passaic Valley Sewer project?

A. I did, yes, sir.

2083 Q. State what you did in that regard?

A. I took the estimates of the Passaic Valley Sewerage Commission given on page 11 of their report.

Q. Of what year?

A. Dated 1908, I think. The estimate for 1911 was 702,400. The estimate for 1940 was 1,649,440. I have interpolated the year 1920 by direct proportion and I estimated the population in 1920, using the Passaic Valley Sewerage Commission's estimates for 1911 and 1940 as a basis, my estimate being 996,400.

Q. Did you give their estimate of population for the year 1911?

A. I did, yes, sir.

Q. Did you make any studies, and if so, state what, as to the quantity of sewage for which the Passaic Valley project will provide?

A. I have. The maximum flow of sewage for which provision was made by the Passaic Valley Sewers in their original report dated 1908 was 357.4 million gallons per day. The estimated average flow for 1940, 223.4 million gallons per day, is based upon the estimates of the Passaic Valley Sewerage Commissioners and the assumption that three-quarters of the manufacturing wastes will be discharged into the intercepting sewer within a period of ten hours. That is my estimate.

Q. Now, assuming some average flow per capita, will you state

what per capita estimate you made, and discuss this question of the capacity of the trunk sewer and the quantity of sewage to be accommodated?

Mr. Riker: I object on the ground that it is immaterial to this inquiry as to whether this witness believes the capacity of the sewer to be adequate or inadequate, the only question being the effect of the discharge through the proposed sewer upon the waters of the harbor of New York Bay.

The Commissioner: Note the objection of Counsel for the Defendants.

2084 A. I have estimated the average quantity of sewage to be expected from the Passaic Valley District at 125 gallons per capita per day. In 1940, based upon this estimate, the average flow for the entire year will be 206 million gallons per day, basing the calculation upon the estimated population as of 1940, namely, 1,649,440 persons, the estimate of the Passaic Valley Sewerage Commissioners, page 11.

Q. You are speaking of their report?

A. Given in their report on page 11. The estimated average flow in 1920 based upon an average per capita flow of 125 gallons per day, will be 124½ million gallons per day. Assuming the population to be, as I estimated, 996,400, being a straight line interpolation of the estimates of the Passaic Valley Sewerage Commissioners. These estimates together with the estimated maximum rates of flow are given in the table which I have prepared, Table No. 1. This table is as follows:

2085 TABLE 1.

Quantity of Sewage.

Number (1)	Discription. (2)	Assumed Rate of Flow. (3)
1.	Maximum 1940 P. V. S. C.	357.4 M. g. d.
2.	*Average " " " " "	223.4
3.	Maximum gallons per capita per day	217.0
4.	Average " " " " "	135.0
5.	**Maximum, 1920	216.0 M. g. d.
6.	***Average, 1920	134.5 "
7.	Maximum, 1940 (at 125+62.5)	309. "
8.	Average, 1940 (at 125)	206. "
9.	Maximum, 1920 (at 125 — 62.5)	187. "
10.	Average, 1920 (at 125)	124.5 "
11.	Maximum gallons per capita per day	187.5 "
12.	Average " " " " "	125.0 "

Population:

1940—Estimated by P. V. S. C. page 11		1,649,440
1911 " " " " " " "		702,400
1920 " " direct proportion		996,400

*Assuming that three-quarters of manufacturing wastes run off in 10 hours. In defendants' answer p. 9, L. 32, it says:
"The daily average flow in 1940 will not exceed 250,000,000 gals."

**996,400 x 217 or $\frac{357.4}{1,649,440}$

***996,400 x 135 or $\frac{223.4}{1,649,440}$

2086 Q. Now, Mr. Eddy, have you studied the question of the age of the sewage when it would reach the outfall at Robbins Reef?

A. I have, yes, sir.

Q. State how and with what results?

A. To arrive at an understanding of the conditions which will result from the discharge of this sewage, it is important to take into consideration the means of collecting it and the length of time which will be involved in conveying it from the point of interception to the point of discharge at Robbins Reef. The sewers of the communities which will be tributary to the intercepting sewer are designed upon the basis of a velocity of about 2½ feet per second. This, I ought to say is rather an assumption than a matter of direct knowledge, because I do not know from personal examination of the grades just the velocity of each sewer, but from going over the territory and noting the slope of the land, I am of the opinion that

that is a very reasonable estimate of the average velocity, taking it by the large.

Q. That is when it is flowing full?

A. That is when it is flowing full or half full, either one.

Q. What data did you take into consideration?

A. The slope of the ground, as I saw it, which generally conforms in a reasonable way with the slope of the sewers themselves. The sewers, however, will not flow full, not half full, much of the time, and I have assumed that the average velocity, taking it throughout the system of hundreds of miles of sewers will be about 2 feet per second. I have also assumed that the average distance that the sewage would be obliged to flow may be taken at about 3 miles before it reached the intercepting sewer. Obviously some of the sewage will flow a much shorter distance, and some will flow a much longer distance, but in my opinion, three miles is a fair estimate, on which assumption it will require approximately two hours for the
2087 sewage under average conditions to reach the intercepter, and I have therefore estimated that on the average the sewage will be 2 hours old when it reached the intercepting sewer.

Q. Now, what time will it take or will be required to flow through the intercepting sewer?

A. In another table which I have designated as Table No. 2 are given the essential data relating to the intercepting sewer, including the location of each section, its length and size, the rate of fall, and the capacity provided for by the commissioners.

Q. Meaning what commissioners?

A. The Passaic Valley Sewerage Commissioners. This table is taken from page 18 of the Commissioners' Report for 1908.

Cross-examination by Mr. Riker:

Q. This is a copy of one of the tables in the report?

A. Yes, sir.

Q. Have you verified it?

A. I have, yes, sir.

Q. Do you know whether the present plans are the same as they were when that report was published?

A. I do not.

Mr. Riker: I object to the use of this table on the ground that it does not appear to be anything contemplated at the present time.

The Commissioner: Note the objection.

Direct examination by Mr. O'Sullivan (resumed):

Q. Proceed, state the contents of the table?

A. The table is as follows:

TABLE 2.

Lengths, Grades, Sizes, and Capacities of Passaic Valley Main Intercepting Sewer.

No. of section of sewer.	Location. From	To	Length of sewer in feet.	Size of sewer in feet.		Slope of sewer in feet per 1,000 feet.	Capacity allowed for by P. V. S. C. X (mgd).
(1)	(2)	(3)	(4)	(5)		(6)	(7)
1	Prospect St.	Bridge St.	2,120	4 feet 0 in.		.624	15.2
2	Bridge St.	Montgomery St.	1,150	4 " 0 "		.524	17.4
3	Montgomery St.	Warren St.	1,275	5 " 0 "		.537	24.5
4	Warren St.	East 22nd St.	8,275	5 " 6 "		.540	30.8
5	East 22nd St.	East 33rd St.	6,780	6 " 0 "		.525	40.5
6	East 33rd St.	Market St.	9,780	6 " 6 "		.545	50.5
7	Market St.	Boundary Saddle River and Garfield	4,500	7 " 0 "		.545	73.4
8	Boundary Saddle River and Garfield	Hope Ave.	10,850	7 " 6 "		.545	77.0
9	Hope Ave.	River Place	2,310	8 " 0 "		.380	101.0
10	River Place	Lafayette St.	2,810	9 " 0 "		.380	127.7
11	Lafayette St.	Snyder Lane	10,750	9 " 6 "		.400	134.5
12	Snyder Lane	Boundary Nutley and Acquackanonk	3,060	10 " 0 "		.380	155.8
13	Boundary Nutley and Acquackanonk	Joralemon St.	10,790	10 " 6 "		.370	161.7
14	Joralemon St.	Mill St.	4,650	11 " 0 "		.370	180.0
15	Mill St.	Verona Ave.	1,430	11 " 6 "		.380	184.3
16	Verona Ave.	Clark St.	9,530	12 " 0 "		.380	232.9
17	Clark St.	Railroad Place	6,710	12 " 6 "		.380	242.5
18	Railroad Place	Berlin St.	7,610	13 " 0 "		.375	297.2
19	Berlin St.	Pumping Station	6,390	13 " 6 "		.380	357.4
20	Pumping Station	West Side Jersey City	9,170	12 " 0 "	XX	.000	357.4
21	West Side Jersey City	East Side Jersey City	8,495	12 " 0 "		.000	357.4
22	East Side Jersey City	End of tunnel	9,095	12 " 0 "		.000	357.4
23	End of tunnel	To outlet	1,000	6 " 0 "	XXX	.000	357.4
			138,530				

X Passaic Valley Sewerage Commissioners. XX Running full. XXX 4 pipes.

2089 Mr. O'Sullivan: The desirability of the table is urged on the ground that it is the last official publication of the data contained therein issued by the Passaic Valley Sewerage Commissioners.

Q. Have you prepared any other tables along that line?

A. I have. There is another table which I designate as Table No. 3 in which are given the estimates of time required for the sewage to reach the outlet at Robbins Reef, based upon the maximum rate of sewage flow obtained or allowed for by the Passaic Valley Sewerage Commissioners, namely 357.4 million gallons per day. The numbers in column 1 of this table correspond to the number in column 1 of Table No. 2, and indicate the sections of the sewer to which the figures in the other columns apply.

Cross-examination by Mr. Riker:

Q. Was this table made up upon independent calculation.

A. Yes, sir, based however, on Table No. 2, which I have previously referred to, and which was taken from the Passaic Valley Sewerage Commissioners' Report.

Q. And this table depends for its value entirely upon the accuracy of your assumed figures in Table No. 2?

A. From my figures which I copied, yes, sir.

Q. Well you assumed them to be correct, did you not?

A. I copied them from the report and they were there stated to be correct.

Q. Do you or do you not assume them to be correct?

A. I assume them to be correct, yes, sir.

Mr. Riker: I object to the figures in this Table on the same ground as my last objection to Table No. 2 with the added objection that the independent work in this table is based upon an assumption which this witness has not verified.

Direct examination by Mr. O'Sullivan (resumed):

2090 Mr. O'Sullivan: The table is urged on the ground that it is based on the last official public expression as given in the report of the Passaic Valley Sewerage Commissioners for 1908, and is the only available source of information upon the subject.

Mr. Riker: Inasmuch as counsel puts these remarks on the record, I desire also to interpolate on the record that the Passaic Valley Sewerage Commissioners are under the jurisdiction of the Supreme Court of the United States, and can be compelled to even produce its present records at this hearing and they are the best evidence in this case.

The Commissioner: Note the objection.

Q. State the contents of that table, Mr. Eddy?

A. The table is as follows:

2091 TABLE 3.

Time Required for Sewage to Reach Outlet.

Maximum Rate Allowed for by Passaic Valley Sewerage Commissioners. Total, 357.4 Million Gallons Per Day.

n — .015.

No. of section of sewer.	Quantity of sewage, m. g. d.	Length of sewer in feet.	Quantity, sewer flowing full, m. g. d.	Velocity of sewage flow.		Time to traverse section, seconds.	Time required to reach out-
				Sewer full, ft. per sec.	Ft. per sec.*		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	15.2	2,120	20.0	2.5	2.8	757	9.50
2	17.4	1,150	18.1	2.3	2.6	442	9.29
3	24.5	1,275	33.2	2.7	2.9	440	9.17
4	30.8	8,275	44.0	2.9	3.1	2,670	9.05
5	40.5	6,780	54.9	3.0	3.3	2,055	8.31
6	50.5	9,780	68.5	3.3	3.6	2,720	7.74
7	73.4	4,500	83.4	3.5	4.0	1,125	6.98
8	77.0	10,850	99.6	3.6	4.0	2,710	6.61
9	101.0	2,310	101.0	3.1	3.1	745	5.92
10	127.7	2,810	139.0	3.5	4.0	703	5.71
11	134.5	10,750	161.5	3.5	3.9	2,755	5.51
12	155.8	3,060	182.8	3.5	4.0	765	4.74
13	161.7	10,790	203.5	3.7	4.1	2,630	4.53
14	180.0	4,650	229.5	3.8	4.2	1,107	3.80
15	184.3	1,430	260.5	3.9	4.2	340	3.49
16	232.9	9,530	294.0	4.0	4.4	2,165	3.41
17	242.5	6,710	329.5	4.2	4.6	1,460	2.80
18	297.2	7,610	358.5	4.2	4.7	1,620	2.38
19	357.4	6,390	400.6	4.3	4.9	1,303	1.93
20	357.4	9,170	.....	...	4.9	1,870	1.57
21	357.4	8,495	.....	...	4.9	1,732	1.05
22	357.4	9,095	.....	...	4.9	1,855	.57
23	357.4	1,000	.....	...	4.9	204	.06
		Total	138,530				34,173 sec.
			25 miles				—9.49 hrs.

NOTE.—No allowance made for period of storage in collecting system or settling tanks.
x Quantity Column 2.

2092 Q. Have you described that Table No. 3 as to what is contained in the different columns, and how you reached the estimate?

A. I will describe it. The quantities of sewage given in Column 2 are those expected to be discharged into the intercepting sewer in the year 1940 and are taken from the Commissioners' report, page 17. The lengths of the several sections given in Column 3, are those which have been taken from the Commissioners' Report. In Column 4 the quantities of sewage which the sewer will accom-o-date when flowing full. These also I have calculated. In Column 5 are given the velocity of sewage flow in feet per second when the sewer is flowing full, under which conditions it has a capacity considerably in excess of the quantities allowed for by the commissioners and given in Column No. 2.

The velocities of sewage flow, in feet per second, for the quantity of sewage allowed for by the Commissioners, are given in column 6. In column 7 is given the time in seconds required for sewage to traverse each section. The time required to reach the outlet, in hours, at these velocities, is given in column 8. For example, the sewage entering the first section—that is, the portion of the sewer between Prospect and Bridge Streets, in Paterson, assuming that all of the sewage enters at the upper end of the section, will require 9.5 hours to reach the outlet at Robbins Reef, making no allowance for the period required to traverse the municipal sewers in Paterson nor for the period of storage in the tanks, as prescribed in the government agreement. In other words, column 8 gives the estimated time of flow through the intercepting sewer from the upper end of each section of sewer to the outlet at Robbins Reef.

In estimating the time required to flow through the sewer, from the pumping station to the end of the tunnel it has been assumed that the velocity of flow would be sufficient to accom-odate the rate of flow in the gravity sewer, which is 13 feet 6 inches in diameter.

In considering the estimates of time given in Table 3,
2093 it should be remembered that they are based upon the assumption that the sewer will be discharging continuously at the maximum rate allowed for by the Commissioners, in 1940—namely, 357.4 million per day.

Q. Have you prepared any other table that will tend to show the time required for sewage to reach the outlet?

A. I have. I have prepared a table similar to Table No. 3, based on the estimated average rate of flow of sewage in 1940 as estimated by the Passaic Valley Sewerage Commissioners.

Q. Did you make any allowance in that table for the period of storage in the collecting system or the settling tanks?

A. There is no allowance made for those two periods in this table.

Cross-examination by Mr. Riker:

Q. This estimate of the commissioners is found in the same report?

A. Yes, sir.

Q. And you have verified it in the same way?

A. I have not, except by reference to their report. No verification of my own; no estimate of my own.

Q. It is an estimate of the commissioners themselves, is it not?

A. Yes, sir.

Q. And made in their printed report in 1908?

A. Yes, sir.

Q. Do you know whether in the present plans which are being put into actual operation, they are relying upon those estimates?

A. I do not.

Mr. Riker: I object to the table on the same grounds as those urged against the use of Table No. 3.

The Commissioner: Note the objection.

Direct examination by Mr. O'Sullivan (resumed):

Q. State the contents of that table, Mr. Eddy?

2094 TABLE 4.

Time Required for Sewage to Reach Outlet.

Average Rate Allowed for by Passaic Valley Sewerage Commissioners. 223.4 Million Gallons Per Day, 1940.

n — .015.

No. of section of sewer.	Quantity of sewage m. g. d.	Length of sewer in feet.	Velocity of sewage flow, ft. per sec.	Time to traverse sections (seconds).	Time required to reach outlet. hrs.
(1)	(2)	(3)	(4)	(5)	(6)
1	9.5	2,120	2.5	848	11.27
2	10.8	1,150	2.4	479	11.04
3	15.3	1,275	2.6	490	10.90
4	19.2	8,275	2.8	2,900	10.78
5	25.3	6,780	2.9	2,340	9.96
6	31.5	9,780	3.2	3,055	9.30
7	45.8	4,500	3.6	1,250	8.45
8	48.0	10,850	3.6	3,010	8.10
9	63.0	2,310	3.3	700	7.26
10	79.6	2,810	3.6	781	7.07
11	83.9	10,750	3.5	3,070	6.85
12	97.1	3,000	3.6	850	6.00
13	101.0	10,700	3.7	2,920	5.75
14	112.5	4,650	3.8	1,223	4.96
15	115.0	1,430	3.7	387	4.02
16	145.0	9,530	4.0	2,380	4.52
17	151.0	6,710	4.1	1,635	3.85
18	185.0	7,610	4.2	1,814	3.39
19	223.0	6,390	4.4	1,450	2.89
20	223.0	9,170	3.1	2,955	2.49
21	223.0	8,495	3.1	2,740	1.06
22	223.0	9,005	3.1	2,930	.90
23	223.0	1,000	3.1	323	.09
			Total	40,590 sec.	
		138,530-		-11.27 hrs.	
		26 miles.			

NOTE.—No allowance made for period of storage in collecting system or settling tanks.

2095 Q. How did you reach the estimates given in Table No. 4?

A. In just the same way as those given in No. 3. In estimating the quantity of sewage to reach the several sections of the intercepting sewer, I have allowed a factor of 223.4 divided by 457.4 of the capacity allowed for by the commissioners as given in Table No. 2, which enters into the calculation. The total time required in the case of this flow, which is 223.4 million gallons per day is 11.3 hours from the upper end of Section 1.

Q. Did you prepare any other table based on these figures?

A. I have prepared a table based on my own estimate of the

quantity of sewage likely to be discharged into the interceptor namely 125 gallons per capita as based on the estimated population as of 1940, printed in the Passaic Valley Sewerage Commissioners' Report. In this case the total average flow is estimated at 206 million gallons per day. I have numbered the table 5 and the columns of calculations are the same as those in the three preceding tables.

Q. In compiling that table, did you make any allowance for the period of storage in the collecting system or in settling basins?

A. I have not. The total length of time exclusive of the time required in the collecting system and storage basins is estimated at 14.9 hours.

Cross-examination by Mr. Riker:

Q. What assumptions did you say you put into this table No. 5?

A. I have based this table on my own estimate of the quantity of sewage likely to be discharged into the intercepting sewer.

Q. What other assumption?

A. The population used as of 1940 is the estimate given in the printed report of the Passaic Valley Sewerage Commissioners.

Q. On what other assumption?

A. The length of the sewer section and the grades are the
2096 same as in the other tables, and are taken from the Passaic Valley Sewerage Commissioners' Report.

Q. Have you verified the estimates or the statements of that report with reference to their present adoption by the Passaic Valley Sewerage Commissioners?

A. I have not, sir.

Mr. Riker: Same objection to this as to the last table.

The Commissioner: Note the objection of Counsel for the defendants.

Direct examination by Mr. O'Sullivan (resumed):

Q. What did you take the quantities estimated to reach the several sections of the interceptor as?

A. Those are the quantities given in the report of the Passaic Valley Sewerage Commissioners.

Q. And as they appear in any of these tables, if so, which?

A. They appear in Column 3 of Table No. 7.

Q. We are speaking now of Table No. 5?

A. Table No. 6 would naturally follow.

Q. I was talking about Table No. 5. Now the quantities estimated in that table is what I base my question on. What quantities did you estimate to reach the several sections of the interceptor. Did you have some formula for them?

A. The quantity from the several sections is taken as 206 divided by 357 of the quantity for those sections given in the Passaic Valley Sewerage Commissioners' Report.

Q. And given in what table?

A. And given in Table No. 2 already in. I explained that

formerly, the total flow which I estimated in 1940 is 206 million gallons. The total flow which the Passaic Valley Commission allowed for was 357 million gallons. In apportioning the 206 million gallons, I have allowed the same proportion of that flow to come from the several districts that the Passaic Valley Sewerage Commissioners allowed in the case of the 357 million gallons.

2097 Q. Taking their figures as given in their report altogether?

A. Yes, sir, and applying my estimate of 206 million gallons to it.

Q. State the contents of that table No. 5?

A.—.

2098 TABLE 5.

Time Required for Sewage to Reach Outlet.

Average Rate, 125 gals. per capita—1940. Total, 206 m. g. d.
n — .015.

No. of section of sewer.	Quantity of sewage m. g. d.	Length of sewer in feet.	Velocity of sewage flow, ft. per sec.	Time to traverse sections (seconds).	Time required to reach outlet. hrs.
(1)	(2)	(3)	(4)	(5)	(6)
1	8.7	2,120	2.4	883	11.76
2	10.0	1,150	2.4	479	11.51
3	14.1	1,275	2.6	490	11.38
4	17.7	8,275	2.7	3,070	11.24
5	23.3	6,780	2.9	2,340	10.39
6	29.1	9,780	3.1	3,150	9.74
7	42.2	4,500	3.5	1,285	8.85
8	44.4	10,850	3.5	3,100	8.50
9	58.0	2,310	3.2	722	7.63
10	73.5	2,810	3.6	780	7.43
11	77.5	10,750	3.5	3,075	7.22
12	89.9	3,060	3.5	875	6.36
13	93.0	10,790	3.6	3,000	6.13
14	103.8	4,650	3.7	1,258	5.28
15	106.5	1,430	3.7	386	4.93
16	134.0	9,530	3.9	2,440	4.85
17	140.0	6,710	4.0	1,680	4.15
18	171.0	7,610	4.1	1,860	3.66
19	206.0	6,390	4.3	1,485	3.17
20	206.0	9,170	2.8	3,275	2.75
21	206.0	8,495	2.8	3,030	1.84
22	206.0	9,095	2.8	3,250	1.00
23	206.0	1,000	2.8	357	0.10
		Total 138,530- 26 miles.			

NOTE.—No allowance made for period of storage in collecting system or settling basins.

2099 Q. Now, take the condition of the sewage at the earliest stage when it will be practicable to put this project into operation, if the construction should be begun in the immediate future. Have you made any estimate to show what the time of the

passage of the sewage through the intercepting sewer would be, taking as a basis 125 gallons per capita average flow of sewage in 1920?

A. I have.

Q. State what that is?

Mr. Riker: The question is objected to on the ground that it is based on a hypothesis that is not supported by any evidence in the case, and is a mere guess; must be a mere guess.

The Commissioner: Note the objection of counsel for defendants.

Mr. O'Sullivan: Counsel for Complainants would like to state in reply to Counsel for Defendants that everything relating to this project is based upon assumptions, the matter not being in existence yet. From its very nature it has to be assumed as not a foot of earth has yet been dug in furtherance of the projected scheme.

A. I have prepared a table similar to the five preceding tables, based upon an estimated flow of 125 gallons per capita as of 1920, the earliest date at which the finished system could be put into use. This table is No. 6.

Q. In compiling this table did you make allowance for the period of storage in the collecting system or in the settling basins?

A. I did not.

Cross-examination by Mr. Riker:

Q. You have said you have selected the year 1920 as the year upon which you have based this table. Why do you do that?

A. Because it seems to me the system might be constructed and put into use by that time. That would allow a reasonable length of time for its construction on the assumption that
2100 the work was to begin immediately.

Q. That is your judgment?

A. That is my judgment; yes, sir.

Mr. Riker: I object to this table on the ground that it has not any foundation at all except the witness' biased judgment in regard to the possibilities of work in a territory with which he is not familiar.

Mr. O'Sullivan: Counsel for Complainants desires to take exception to the expression "biased" as there is no evidence of the slightest kind that this witness, who has already testified to his intimate knowledge of the Passaic Valley drainage area, having been employed by New Jersey Municipalities for that purpose, there is no evidence that he has evinced the slightest bias in this matter.

The Commissioner: Note the objection of counsel for defendants.

Direct examination by Mr. O'Sullivan (resumed):

Q. State the contents of that table, Mr. Eddy?

A. The table is as follows:

2101 TABLE 6.

Time Required for Sewage to Reach Outlet.

Average Rate, 125 gals. per capita, 1920. Total, 124.5 m. g. d.
n — .015.

No. of section of sewer.	Quantity of sewage m. g. d.	Length of sewer in feet.	Velocity of sewage flow, ft. per sec.	Time to traverse sections (seconds).	Time required to reach outlet. hrs.
(1)	(2)	(3)	(4)	(5)	(6)
1	5.3	2,120	2.1	1,010	14.90
2	6.0	1,150	2.1	548	14.60
3	8.5	1,275	2.2	580	14.45
4	10.7	8,275	2.3	3,596	14.30
5	14.1	6,780	2.5	2,710	13.30
6	17.6	9,780	2.7	3,620	12.58
7	25.5	4,500	3.1	1,450	11.55
8	26.7	10,850	3.0	3,620	11.15
9	35.1	2,310	2.8	825	10.15
10	44.4	2,810	3.1	907	9.93
11	46.8	10,750	3.0	3,585	9.69
12	54.1	3,060	3.1	987	8.68
13	56.2	10,790	3.1	3,480	8.40
14	62.5	4,650	3.2	1,452	7.43
15	64.2	1,430	3.1	461	7.03
16	81.0	9,530	3.4	2,805	6.90
17	84.4	6,710	3.5	1,920	6.13
18	103.0	7,610	3.6	2,115	5.59
19	124.5	6,390	3.8	1,680	5.00
20	124.5	9,170	1.7	5,390	4.54
21	124.5	8,495	1.7	4,999	3.04
22	124.5	9,095	1.7	5,350	1.65
23	124.5	1,000	1.7	588	0.16
		Total 138,530- 26 miles.			

NOTE.—No allowance made for period of storage in collecting system or settling basins.

2102 Q. Upon what did you base the estimates of the quantity of sewage in that table?

A. These estimates are based on my estimate of the quantity of sewage to reach the intercepting sewer, namely 125 gallons of sewage per capita per day, and upon the estimate of population which I made as based upon the estimates of the Passaic Valley Sewerage Commissioners of 1911 and 1940. The maximum time required under these conditions would be 14.9 hours from the upper end of Section 1 to the outlet at Robbins Reef.

Q. How did you compute the quantities of sewage?

A. You mean in Table 6?

Q. Upon which these estimates are based?

A. In the same manner as those of the previous 4 tables, using 125 gallons per capita, and the estimated population for 1920 interpolated from the estimates of 1911 and 1940 of the Passaic Valley Sewerage Commissioners.

Q. Did you make any other estimate?

A. I have made no other estimate of this kind. I have summarized these estimates in Table No. 7.

Q. With a view to showing what?

A. With a view to showing the length of time required for the sewage to reach Robbins Reef Outlet under the several conditions mentioned. First, the maximum flow allowed for by the Passaic Valley Sewerage Commissioners, 357.4 million gallons per day. Second, the average flow allowed for by the Passaic Valley Sewerage Commissioners 223.4 million gallons per day. Third, the estimate as of 1940, at the rate of 125 gallons per capita, or 206 million gallons per day. Fourth, the estimate as of 1920, based on 125 gallons per capita as the estimated flow in 1920. Upon this assumption the total average flow from the district will be 124.5 million gallons per day. I have allowed in each case two hours for the flow
2103 to pass through the local collecting system, and the times shown in Tables 3, 4, 5 and 6 for the flow to pass through the intercepting sewers. I have also allowed in the case of the maximum rate of flow in 1940 for one hour in the storage or sedimentation tanks, and for the other rates of flow 1.5 hours. The last column, Column 7 is a summation of these times ranging from 12.5 hours in the case of the maximum rate of flow in 1940 to 18.4 hours the estimated average time required in 1920.

Mr. Riker: I object to the insertion of the table in the evidence in this case, for the reason that it appears by the witness' statement to be based upon the other tables which have been introduced under objections and will be subject to the general objection that it is not founded upon any evidence of actual fact in this case. It is based on assumptions not even verified as assumptions, upon which the Passaic Valley Sewerage Commissioners, one of the defendants in this case, is proceeding.

The Commissioner: Note the objection of Counsel for Defendants.

Q. State the contents of that table, Mr. Eddy?

A. The table is as follows:

2104 TABLE 7.

Time Required for Sewage to Traverse the Passaic Valley Sewer under Different Conditions.

Number.	Description.	Assumed rate of flow m.g.d.	Time in— Municipal sewers.	Time in— Interceptor.	Time in— Settling tanks.	Total max. time.
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1.	Max. 1940 P. V. S. C.....	357.4	2 hrs.	9.5 hrs.	1 hr.	12.5 hrs.
2.	Avg. " " " "	223.4	2 "	11.3 "	1.5 hr.	14.8 "
3.	" " (at 125).....	206.0	2 "	11.7 "	1.5 "	15.2 "
4.	" 1920 " "	124.5	2 "	14.9 "	1.5 "	18.4 "

Q. Mr. Eddy, did you take into consideration the questions dealing with the variation of the rate of flow and the quantity of sewage discharged per hour or proposed to be discharged per hour at Robbins Reef?

A. I have, yes sir.

Q. State what you did with regard to that?

A. I have estimated first the maximum quantity of sewage likely to be discharged at Robbins Reef.

The Commissioners have allowed for 357.4 million gallons of sewage per day but have assumed that the sewers would be running only part full. The largest section of the sewer, 13 feet 6 inches in diameter, is in the vicinity of Newark and leads to the pumping station. The maximum capacity of this sewer, assuming that it does not work under a head, is 432 million gallons per day, or 121 per cent. of the allowance of the Commissioners.

The sewers of the City of Newark and of several other cities which will be tributary to the intercepter, if built, are provided with the combined system of sewers, by which is meant a system composed of single lines of sewers in the streets, each sewer receiving both
2105 sewage and storm water. The quantity of storm water which can be disposed of by the intercepter is relatively small, even if the intercepting sewer is working at its utmost capacity. It therefore follows that relatively moderate storms, such as summer rains and short showers, will furnish sufficient run-off from the streets to fill the intercepter. It is therefore evident that it will be possible to discharge at Robbins Reef, the maximum quantity of sewage which can be forced through the largest section of the sewer tributary to the pumping station, which quantity is 432 million gallons per day, equivalent to 18 million gallons per hour.

If it is assumed that the maximum rate of flow from the intercepter will be that provided for by the Commissioners, 357.4 million gallons per 24 hours, the quantity actually discharged per hour will be practically 15 million gallons.

Hourly Variation in Rate of Flow. The quantity of sewage discharged into a sewer system varies greatly from hour to hour and slightly from day to day. The hourly variation in the flow, in a small system of sewers, may range from a minimum of 50 per cent. of the average flow to a maximum of 200, or more per cent. of the average flow.

The variation in the rate of flow in intercepting sewers serving large communities is much less than in sewers serving relatively small districts. The best available records of the rate of sewage flow in intercepters serving large districts are those of the North and South Metropolitan Districts in Massachusetts. The curves shown in Figure 1 are taken from the North Metropolitan District the week beginning November 2, 1908 the South Metropolitan District, the week beginning November 8, 1908 and the curve which has been calculated for the Passaic Valley intercepter.

Q. Have you got those curves?

A. I have, yes, sir.

Q. Before offering those, Mr. Eddy, will you give me the
2106 lengths of the Metropolitan intercepting sewers?

A. The lengths of the Metropolitan intercepting sewers are as follows:

North Metropolitan Sewer from outlet to upper end in Stoneham, 17.0 miles.

North Metropolitan Sewer, above gaging point (near Everett-Chelsea Line) 11 miles.

South Metropolitan Sewer from outlet to upper end at Waltham line, 21.5 miles.

South Metropolitan Sewer, above gaging point (Including district above Ward Street pumping station, 18 miles.

Q. This chart purporting to show the Hourly Variation in flow of sewage in Massachusetts Metropolitan Districts and Estimated Hourly Variation in flow in Passaic Valley Sewer at Pumping Station, that was prepared where?

A. It was prepared in my office.

Q. Under whose direction?

A. Under my direction.

Mr. O'Sullivan: I offer the chart showing the curve described by by this witness in evidence and ask that it be marked Complainants' Exhibit No. 128.

Cross-examination by Mr. Riker:

Q. This curve which you have indicated, a blue print of which you have produced, so far as it relates to the Passaic Valley Sewer, where did you get your data upon which to lay out this curve?

A. I have calculated the quantity of sewage from each community as based upon a curve which in my judgment will represent the rate of discharge from the community.

Q. Where did you get your figures of the discharge from the community?

A. I have estimated that at 125 gallons per capita per day.

Q. Is that a recognized basis for the estimate of sewage discharge per capita?

A. It is a common one.

Q. Is there any recognized basis of computation of sewage?

A. I should hardly say there was, although, of course,
2107 there are some figures which have been used commonly.

Q. Why do you use 125 in this case?

A. Because in my judgment that was the quantity which would be discharged.

Q. Upon what was your judgment based?

A. Upon experience in various communities, partly upon the quantity of sewage discharged from the North Metropolitan System at Boston; partly upon studies which I have made in Milwaukee and Worcester, Marlboro, Gloversville, East Orange.

Q. East Orange, do you know East Orange is essentially a residential district of the County of Essex, and of this Passaic Valley Sewerage District?

A. I do.

Q. And is it or is it not in your judgment a fair basis as an average for computation of the whole district?

A. I would not say that it was.

Q. So that how does that furnish you a basis for calculation?

A. Because it is one of the communities which I expected would form part of this district, and its flow should be considered.

Q. You did expect it to be?

A. Yes, sir.

Q. It is one of the districts that you designed an independent system for?

A. Yes, sir.

Q. And you expected it to form part of this system?

A. I understood that it was, yes, sir.

Q. Well, how does it assist you in forming a basis of 125 for the whole district, if it is exceptional?

A. Because it is one of the districts which will furnish sewage to make up this flow.

Q. Unless you know something of actual facts in regard to the other municipalities or communities, how does it help you to form any estimate?

A. But I do know something about the other communities.

Q. What do you know about the flow in Newark?

A. I know about the character of the city and the flow
2108 which should be expected to come from there.

Q. About what is the actual per capita flow from the City of Newark?

A. I do not know, sir.

Q. What is the actual per capita flow from the City of Paterson?

A. I do not know, sir.

Q. What is the actual per capita flow from the Town of East Newark?

A. I do not know.

Q. Or the Town of Harrison?

A. I do not know.

Q. Then what value has your knowledge of East Orange on this problem?

A. It aids me in forming a judgment of the flow from the entire district.

Q. Being an exceptional community how does it aid you in determining the general flow?

A. I do not know that it is an exceptional community.

Q. Have you not said it was an exceptional community?

A. I do not think so.

Q. Is it not an exceptional community?

A. I do not think it is.

Q. Don't you know it is a strictly residential community as compared with the large manufacturing towns, Newark and Paterson?

A. Yes, but I do not know that one is more exceptional than the other.

Q. Do you not think that there is any difference between a manufacturing community and a high class residential district?

A. I did not say that.
Q. I asked you whether you think there is a difference?
A. I do think there is.
Q. Do you know that East Orange may be properly termed a high-class residential district?
A. I should judge so.
Q. And the City of Newark may properly be called a manufacturing community?
A. Yes.
Q. And the City of Paterson?
A. Yes.
Q. And the Town of Harrison?
A. I judge so.
2109 Q. And a good deal of the Borough of East Newark?
A. I should judge so.
Q. What other assumptions have you made in laying out the curve for the Passaic Valley Sewerage District on this chart?
A. I have calculated the length of time taken for the sewage to reach from several communities to pumping station.
Q. Well, how does that help you in determining the hourly variations in the flow of sewage?
A. Because the length of time enters into the cumulative quantity which you receive at the pumping station. You must take into consideration not only the quantity of sewage to be expected, but also the length of time taken to reach the pumping station from the point of original discharge.
Q. Have you any facts from actual observations upon which this curve is based?
A. The facts upon which it is based, my judgment. It is largely an estimate.
Q. It is not entirely an estimate?
A. I should say it was entirely an estimate, or a matter of judgment.
Q. There is no one fact in the whole series of facts which were necessary in order to enable you to lay out this graphic illustration, which is based upon actual observation?
A. From actual measurement, no, sir.
Q. Is that true of the other curves that are delineated on this offer or exhibit?
A. The other curves are made up from the actual measurements.
Q. Made by whom?
A. Taken by automatic gauge from Metropolitan sewers.
Q. And coming to your attention in what way?
A. I went over and got the record from the record charts.
Q. Who laid out these curves?
A. I did.
Q. You did the work?
A. Yes, sir.
Q. I think you said you supervised it?
A. I supervised the drawing, I did not make the drawing, the final inking in of the blue print.

2110 Q. You mean the inking in of the tracing?
A. Of the tracing.

Mr. Riker: The offer is objected to insofar as it relates to the Passaic Valley Sewerage Commission's project on the ground that it is purely arbitrary and hypothetical, and as to the other two curves on it, that they are immaterial and irrelevant to this inquiry.

The Commissioner: Note the objection of Counsel for Defendants.

Direct examination by Mr. O'Sullivan (resumed):

Q. Mr. Eddy, is the South Metropolitan District Sewer in operation?
A. Yes, sir.
Q. Did you get your estimate from the actual official publication?
A. No, sir, they were not taken from printed records.
Q. What were they taken from?
A. From the office records.
Q. Is the North Metropolitan Sewer in operation?
A. Yes, sir.
Q. And how did you get your figures for basing your estimate and fashioning the curve on?
A. In the same way, from the office records.
Q. Is the Passaic Valley Trunk Sewer in operation?
A. No, sir.
Q. Are there any of these New Jersey municipalities where they actually measure the flow of sewage?
A. I do not know of any.
Q. Is there any other way that you could get accurate determinations of the amount of sewage per capita discharged from the municipalities?
A. I do not think so.

Cross-examination by Mr. Riker:

Q. You say you do not know of any measurements?
A. No.
Q. Do you not know the discharge from Orange and Montclair and Bloomfield?
A. I do not, no, sir.
2111 Q. Do you not know that they are measured?
A. I do not, no sir.
Q. You know East Orange is?
A. I know East Orange was for a time.
Q. For what time?
A. I do not remember.
Q. Have you ever made any inquiry to find out whether there are measurements of the amount from these Essex County municipalities?
A. I do not think I have.

Mr. Riker: That is all.

The Commissioner: Received and marked Complainants' Exhibit No. 128.

Marked Complainants' Exhibit No. 128.

Direct examination by Mr. O'Sullivan (resumed):

Q. Directing your attention to Complainants' Exhibit No. 128, Mr. Eddy, what would you say with regard to the variation in flow of the South Metropolitan curve as shown on that?

A. I have used that curve as a general guide. The variation in the flow of the South Metropolitan system is not strictly applicable, as there is a long length of sewer above the gauging point, in which there are few connections, and in which the velocity is low. Under such conditions the variations are less than they would be if used more nearly to its capacity.

Q. Now, as to the North Metropolitan?

A. North Metropolitan is more comparable with the conditions which I should expect in the Passaic Valley Trunk Sewer. The North Metropolitan System above the gauging point has many branches and is more similar to the collection system of a large city than to a long intercepting sewer serving many municipalities as will be the Passaic Valley trunk sewer. Furthermore, the districts tributary to the upper portions of the North Metropolitan sewer are sparsely built and contribute very little sewage, as compared with that which will be tributary to the upper portions of the Passaic Valley trunk sewer.

2112 Q. Taking into consideration the relatively large proportions of the flow that will be contributed to the Passaic Valley trunk sewer by the cities of Paterson and Passaic, how will that influence it?

A. While I have used these curves of the north and south Metropolitan Sewers as a general guide and check, I have calculated the probable flow in the Passaic Valley Sewer from hour to hour, basing these calculations upon the quantity of sewage estimated to be discharged in the Passaic Valley Sewer and the length of time which will be required for that sewage to reach the pumping station.

Q. Did you prepare any table to show the period of time required for the sewage to pass from the sections of the intercepting sewer to the outlet at Robbins Reef?

A. In Table 8, column 2 are given the periods of time required for sewage to pass from the several sections of the intercepting sewer to the outlet at Robbins Reef, no allowance being made for time in the settling basins. These periods of time are taken from Table 5. By deducting the time required for the sewage to flow from the pumping station to the outlet the time required to reach the pumping station has been figured. The several periods of time given in column 3 have been calculated in this manner. The periods of time given in column 5 are estimates of the time required for the sewage from the several communities to reach the pumping station,

based upon the periods of time given in column 3, due consideration being given to the length of the several sections and the quantity of sewage discharged into them.

Cross-examination by Mr. Riker:

Q. This table, Mr. Eddy, I understand is based upon tables which you have already testified to?
A. Yes, sir.

Q. And contains certain assumptions that are contained in those?
A. Yes, sir.
Mr. Riker: I object on the same grounds as the objections to the other tables.

2113 The Commissioner: Note the objection of Counsel for Defendants.

Direct examination by Mr. O'Sullivan (resumed):
Q. State the contents of that Table No. 8 Mr. Eddy?

2114 TABLE 8.

Estimated Time for Sewage from Various Communities to Reach Pumping Station and to Reach Outlet.

(Avg. Flow, 206 m. g. d.)

No. of section of sewer.	Time required to reach outlet (hrs.)	Time required× to reach pumping sta. (hrs.)	Name of community.	Estimated time required for sewage of community to reach pumping station (hrs.).
1	11.75	9.01		
2	11.51	8.76		
3	11.38	8.53		
4	11.24	8.49	Paterson.	7.5
5	10.39	7.64		
6	9.74	6.99		
7	8.85	6.10		
8	8.50	5.75		
9	7.63	4.88	Passaic.	5.25
10	7.43	4.68		
11	7.22	4.47		
12	6.36	3.61	Communities	
13	6.13	3.38	between Passaic	
14	5.28	2.53	and Newark.	3.5
15	4.93	2.18		
16	4.83	2.08		
17	4.15	1.40		
18	3.68	0.93	Newark.	1.25
19	3.17	0.42		
20	2.75	0.00		
21	1.84			
22	1.00			
23	.10			

× From upper end of section.

2115 Q. Did you prepare any other table to get the proportion of sewage flow contributed by any of the towns?

A. In Table No. 9 are given the proportions of Sewage Flow contributed by Paterson, Passaic, towns between Passaic and Newark and the time required for the sewage from each community to pass to the pumping station, based upon an estimated average flow in 1940 of 125 gallons per capita per day or a total or 206 million gallons per day.

Q. Where did you get the basis for that?

A. The proportion of sewage flow contributed by each community has been obtained from Table 7 of the Commissioners' Report page 17.

Q. What Commissioners?

A. The Passaic Valley Sewerage Commissioners. The districts are as follows:

Paterson, Prospect Street, to Boundary Saddle River and Garfield.
Passaic, Boundary Saddle River and Garfield to Snyder Lane.
Small Towns, from Snyder Lane to Mill Street.
Newark, Mill Street to Pumping Station.

Cross-examination by Mr. Riker:

Q. Do you know whether Garfield is included within the Passaic Valley Sewerage District?

A. As at present, I do not.

Q. Do you know whether it ever was?

A. I do not, except from the report. It is given as a boundary.

Q. In the general district that you have classified as Passaic, what municipalities are included?

A. I do not know that I have a list of those cities here. They are taken from the printed report.

Q. Below Belleville, have you got the municipalities?

A. I cannot give them from memory.

Q. Do you know whether Orange, East Orange, Glenwood, and Bloomfield are included?

A. I assumed it.

2116 Q. Why?

A. Because they are included in the printed report upon which I based my calculation.

Q. Do you know that the project as it is now in operation is based upon a contract in which none of those municipalities have joined?

A. I do not.

Q. If they are not in the project, your figures are not accurate, are they?

A. Not strictly, no, sir.

Q. That throws your estimate out very considerably?

A. Why, to a limited extent.

Q. And if the smaller towns which you have spoken of as in the Passaic District are, as a matter of fact not in the district, that also influences your estimate?

A. It would.

Q. And influences the value of this table?
A. To a certain extent, yes, sir.

Mr. Riker: I object to the table on the ground that it does not appear to be based upon facts, but upon assumptions which are not even attempted to be verified by this witness.

Direct examination by Mr. O'Sullivan (resumed):

Q. Mr. Eddy, where did you get the facts?
A. From the printed report of the Passaic Valley Sewerage Commissioners dated 1908.
Q. So that if any of those facts are erroneous, they were erroneous in that report?
A. Yes, sir.

Cross-examination by Mr. Riker:

Q. That report, Mr. Eddy, is an estimate, is it not?
A. Well, in the nature of a preliminary report.
Q. Purporting to include estimates?
A. Of the proposed project.
Q. Purporting only to be an estimate?
A. Some factors in it, are estimates, of course.
Q. Do you know there is an actual contract; you have heard there is an actual contract in force?
A. I have not, except from your statement of it.
2117 Q. A contract between certain municipalities and the Passaic Valley Sewerage Commissioners?
A. I did not know that.
Q. You did not know that?
A. No, sir.

Direct examination by Mr. O'Sullivan (resumed):

Q. State the contents of that Table 9, Mr. Eddy?
A. The table is as follows:

TABLE 9.

Proportion of Sewage Flow and Time Required to Reach Pumping Station by Sewage of Paterson, Passaic, Various Small Towns, and Newark.

	Quantities m. g. d.	% of total sewage flow.	Time to reach pumping sta. avg. 125 gals. per cap. 1940 (206 m. g. d.).
Paterson	42.23	20.5	about 7.5 hours
Passaic	35.02	17.0	" 5.25 "
Below Belleville ..	26.37	12.8	" 3.5 "
Newark	102.38	49.7	" 1.25 "
	206.00	100.0	

Q. Have you prepared any diagram, Mr. Eddy, showing the curves of the sewage flow at each hour of the day in a number of cities that has guided you in making your estimate of the probable hourly discharge from the Passaic Valley Sewerage outfall?

A. I have used, in forming my judgment, the diagram which I have used in other places, which is made up of a number of measurements of the flow of sewage at different hours of the day and on which I have plotted a main curve. I have used this diagram in forming my judgment in this particular case.

Q. What kind of cities did you use there?

A. The cities of Milwaukee, Wisconsin, Worcester, Massachusetts, Marlboro, Massachusetts, Toronto, Canada, Gloversville, New York, East Orange, New Jersey, Birmingham, England.

Q. Why did you select these particular cities?

A. Those were the cities from which I had data, which
2118 seemed to me to be reliable.

Q. Are they cities representative of the type of municipality that contemplates entering into the Passaic Valley Sewerage project?

A. I think they are.

Q. Have you got that chart or diagram here?

A. I have.

Mr. O'Sullivan: I offer this chart or diagram purporting to show the hourly variation in flow of sewage in various cities, the curve showing also the average with all gaugings. I offer it in evidence and ask that it be marked Complainants' Exhibit No. 129.

Cross-examination by Mr. Riker:

Q. Was this copy of the curve made by you?

A. Made under my direction. It was made some years ago, and I cannot say exactly whether I made every computation or not.

Q. Has it been accepted as a standard by other engineers?

A. I do not know that it has. I have based considerable of my work upon it.

Q. You say that you think that these cities that are represented on this curve are typical of the cities and towns in the Passaic Valley Sewerage District?

A. I think some of them are. There are some of which I could hardly answer that question.

Q. In what respect is Malwaukee, Wisconsin, similar to any of the cities or municipalities in the district?

A. It is a large city, provided with combined sewers, much like Newark, not very dissimilar from Paterson or Passaic.

Q. What is the size of Milwaukee?

A. As I remember it, about 375,000 population.

Q. At what census?

A. 1910.

Q. It is a manufacturing city?

A. It is, yes sir.

Q. Similar to Newark?
A. In a general way, similar to Newark.
Q. Is the topography of the city similar to that of Newark?
A. I think it is somewhat similar.
2119 Q. Well, you think it is. Will you state some points of similarity?
A. Well, it is a rolling country, somewhat hilly, and there is some level land.
Q. There are very few cities that do not answer that description?
A. Some which do not; there are a good many which do.
Q. Is it not a fact that you used it because you had the data?
A. I think I said that, yes, sir.
Q. And that is the chief reason why you used it?
A. Because there I had what I thought was reliable data. I think I said that before.
Q. And is the same true of Worcester?
A. Yes sir.
Q. It is not because Worcester is so similar in detail to any one of the municipalities that you have used it?
A. It is very similar I think to the three which I mentioned. It is an active manufacturing city. I suppose Worcester is more like Newark than most of the other cities.
Q. You had made up this curve long before you were called upon to express any opinion and you used it for general use in your profession?
A. Yes, I did.
Q. And it had no special bearing whatever on this particular problem?
A. Yes sir.

Mr. Riker: I object to the offer on the ground that it is immaterial and irrelevant.
The Commissioner: Note the objection of Counsel for Defendants.

Direct examination by Mr. O'Sullivan (resumed):

Q. Did you take into consideration all the municipalities entering into the Passaic Valley Trunk Sewer project; were some of them manufacturing cities and some residential cities?
A. I did, yes sir.
Q. Have you taken on this chart any purely residential
2120 city?
A. Yes sir.
Q. What one?
A. Well, the City of Marlboro, Massachusetts, a purely residential city, scarcely any manufacturing. The City of East Orange is a residential city.
Q. Was that the city that Mr. Riker emphasized as so peculiarly a residential city?
A. Yes, sir.
Q. The other cities that go to form the data of this curve are what?
A. In what respect?
Q. Of what character?

A. Large manufacturing cities industrial centers.
Q. Mixed residential and manufacturing?
A. Yes, sir.

Mr. Riker: Do you know what communities in the Passaic Valley Sewerage District have actually contracted with the Passaic Valley Sewerage Commissioners to join in this enterprise?
The Witness: I do not.
The Commissioner: Received and marked Complainants' Exhibit No. 129.
Marked Complainants' Exhibit No. 129.

Direct examination by Mr. O'Sullivan (resumed):

Q. Did you prepare a table showing the quantity of sewage flow at the pumping station at different times during the day?
A. I have, yes, sir.
Q. For any of these New Jersey municipalities?
A. Yes, Table No. 10.

Cross-examination by Mr. Riker:

Q. Upon what assumption is this table based?
A. That was based primarily upon the estimate which I made of the quantity of sewage likely to reach the interceptor, namely, 125 gallons per capita per day as of 1940, the population being that given as estimated by the Passaic Valley Sewerage Commissioners.
Q. And assuming what municipalities are going to engage
2121 in this enterprise?
A. Those listed in the printed report.
Q. And you have made no attempt to trace it any more than you said in your answer to my last inquiry to verify what ones are included?
A. No.
Q. And you do not know?
A. No.
Q. You made no inquiry?
A. I have not.
Q. How long have you been back East?
A. I got East Thursday Noon last.
Q. Do you know where the office of the Passaic Valley Sewerage Commissioners is?
A. I do not now, unless it is where it was two years ago. I knew at that time.
Q. You made no attempt to even find out where their office was?
A. I have not, sir.
Q. Do not know that there is a contract in existence between the commissioners and certain municipalities?
A. I do not.

Mr. Riker: I object to the offer on the ground that it is merely conjectural.
The Commissioner: Note the objection.

Direct examination by Mr. O'Sullivan (resumed):

Q. State the contents of that table?

Quantity of Sewage Flowing at Pumping Station at Different Times During the Day. Assuming an Average Flow of 206 m. g. d.

Community.	Paterson.		Passaic.		Belleville.		Newark.		Total.	
Time to reach pumping station.	7½hrs.		5¼ hrs.		3¼ hrs.		1¼ hrs.			
Average daily flow mgd.	42.22		35.02.		28.37.		102.39.		208.00	
Time at pumping station.	Sewage as of	Rate of flow M. G. D.	Sewage as of	Rate of flow M. G. D.	Sewage as of	Rate of flow M. G. D.	Sewage as of	Rate of flow M. G. D.	Time at pumping station.	Rate of flow M. G. D.
2.00 A. M.	6.30 P. M.	40.9	9.45 P. M.	29.5	10.30 P. M.	30.2	12.45 A. M.	69.4	2.00 A. M.	160.0
4.00 "	8.30 "	36.7	10.45 "	25.4	12.30 A. M.	18.1	2.45 "	69.8	4.00 "	150.0
6.00 "	10.30 "	32.5	12.45 A. M.	23.9	2.30 "	17.9	4.45 "	79.7	6.00 "	154.0
8.00 "	12.30 A. M.	29.0	2.45 "	23.6	4.30 "	19.8	6.45 "	117.6	8.00 "	190.0
10.00 "	2.30 "	29.0	4.45 "	27.5	6.30 "	27.5	8.45 "	138.0	10.00 "	223.0
12.00 M.	4.30 "	31.6	6.45 "	40.4	8.30 "	35.9	10.45 "	135.1	12.00 M.	243.0
2.00 P. M.	6.30 "	44.1	8.45 "	47.2	10.30 "	35.1	12.45 P. M.	128.5	2.00 P. M.	255.0
4.00 "	8.30 "	57.1	10.45 "	46.5	12.30 P. M.	33.7	2.45 "	119.7	4.00 "	257.0
6.00 "	10.30 "	56.2	12.45 P. M.	44.3	2.30 "	31.2	4.45 "	108.3	6.00 "	240.0
8.00 "	12.30 P. M.	53.5	2.45 "	41.0	4.30 "	28.7	6.45 "	98.0	8.00 "	221.0
10.00 "	2.30 "	50.1	4.45 "	37.4	6.30 "	25.6	8.45 "	87.9	10.00 "	201.0
12.00 "	4.30 "	46.1	6.45 "	32.5	8.30 "	22.8	10.45 "	76.6	12.00 "	179.0

2123 Q. Referring to that table, Mr. Eddy, will you state what those columns show; how you reached such conclusions as are set forth in those columns?

A. In column 1 are given the hours at which the flow at the pumping station has been calculated. As it required 7½ hours for the sewage of Paterson to reach the pumping station, it follows that the quantity of sewage from Paterson in the flow at the pumping station at 2 A. M. was the quantity discharged into the interceptor 7½ hours prior to that time, or at 6:30 P. M. Therefore, the time given in the second column is 7½ hours earlier than the time given in column 1. From Figure 2 has been taken the percentage of the average flow which will be discharged from a sewer system at 6.30 P. M. and this percentage of the average Paterson flow, 42.23 m. g. d., is 40.9 m. g. d. the rate of sewage discharged into the interceptor from the City of Paterson at 6.30 P. M. In a similar manner, the quantities discharged at Passaic, Belleville and Newark have been calculated. In column 11 are given the rates of flow at the pumping station at the several hours of the day, which is a summation of the rates contributed by the several districts,—for example,—at 2 A. M. the flow at the pumping station is estimated to be at the rate of 160 million gallons per day, which quantity is made up of 40.9 m. g. d. from Paterson, 29.5 m. g. d. from Passaic, 20.2 m. g. d. from Belleville and 69.4 m. g. d. from Newark.

From Table 10 it appears that the maximum rate of sewage flow, under ordinary conditions, will be 257 million gallons per day at which rate 10.7 million gallons of sewage will be discharged at Robbins Reef in 1 hour.

In Table 11 are given the quantities of sewage which will be discharged at Robbins Reef in 1 hour at time of maximum rate of flow under several conditions which will prevail if the Passaic Valley project is carried to completion.

Q. And what is shown in Table No. 11?

2124 A. The quantities of sewage which will be discharged at Robbins Reef in one hour, at the time of maximum rate of flow under the several conditions, which will prevail if the Passaic Valley project is carried to completion.

Cross-examination by Mr. Riker:

Q. Now, what Passaic Valley project are you speaking of?

A. That described in the printed report of the Passaic Valley Sewerage Commissioners of 1908.

Q. And does that involve the municipalities named in that report?

A. Yes, sir.

Q. Do you know whether or not the municipalities named in that report are actually engaged under contract in any project for the construction of a sewer?

A. I do not.

Q. If a considerable number of those named in the project have, as a matter of fact, not joined in the enterprise, will it or will it not affect this table?

A. It will.

Mr. Riker: I object to the reading of the table on the ground that it appears that the table is based on assumptions which this witness has not verified, and which are not verified in this case by the witness.

The Commissioner: Note the objection of Counsel for Defendants.

Direct examination by Mr. O'Sullivan (resumed):

Q. State the contents of that table, Mr. Eddy?

A. The table is as follows:

2125 TABLE 11.

Quantities of Sewage Likely to be Discharged at Robbins Reef in One Hour, Under Several Conditions.

(1)	(2)	M. g. per hour (3)	Depth on 3½ acres (feet.) (4)
1.	Maximum possible flow (432 m. g. d.)....	18	15.8
2.	" rate allowed for by Commissioners (357.4 m. g. d.).....	14.9	13.1
3.	" ordinary rate in 1940, (206 m. g. d.).....	10.7	9.4
4.	" ordinary rate in 1920, (124.5 m. g. d.).....	6.5 —*	5.7*

* This quantity is approximate being based upon maximum percentage calculated upon assumed average rate of flow of 206 m. g. d. i. e., 124.5 x 124.5% — 24 — 6.5 m. g. maximum rate when average rate — 124.5 m. g. d.

Q. What does Table No. 11 show?

A. From Table 11 it appears that the maximum rate of flow will be 124.5% of the average flow. Upon this basis the maximum rate of flow in 1920, assuming the average rate of flow at 124.5 million gallons per day, will be 6.5 million gallons per hour. In column 4, Table 11, are given the depths of sewage discharged during 1 hour, assuming that the entire flow comes to the surface and is restricted to the 3½ acres of dispersion area. For example, if the daily average rate of sewage flow should be 206 million gallons, the quantity of sewage discharged in 1 hour at time of maximum rate of flow would be sufficient to cover 3½ acres of dispersion area to a depth of 9.4 feet.

Q. What studies did you make relative to the quality of this sewage when it reaches the point of discharge at Robbins Reef?

A. The sewage discharged at Robbins Reef will be made up of the sewages from large and small communities, some of
2126 which are purely residential while others are strictly manufacturing in character. It will also be made up of the sewage collected by municipal systems built in accordance with the separate

system plan, which provides that storm water shall be excluded from the sewers, and from municipal systems built upon the combined plan, in which the sewers receive not only the sewage but also vast quantities of refuse from the streets washed into the sewers in times of storm.

The sewage from the North Metropolitan District in Massachusetts is probably as nearly like that which will be collected by the Passaic Valley sewer as any of which we have record. The flow in the North Metropolitan sewer from 1904 to 1909, inclusive, was as follows:

1904	121.5	gallons	per	capita	per	day.
1905	113.5	"	"	"	"	"
1906	119.4	"	"	"	"	"
1907	129.6	"	"	"	"	"
1908	119.0	"	"	"	"	"
1909	118.4	"	"	"	"	"

Q. From these figures what do you conclude?

A. From the foregoing figures it appears that the average flow from the North Metropolitan system has been substantially that which has been estimated for the Passaic Valley project. The communities served by the North Metropolitan sewerage district comprise the cities of Boston and Cambridge, and a number of smaller communities, all of which in size and character are comparable with those of the Passaic Valley project. Some of the cities may be called industrial centers like Newark, Paterson and Passaic, while others are primarily residential in character. It therefore seems reasonable to expect that the sewage collected by the Passaic Valley sewer will be similar in character to that collected by the
2127 North Metropolitan system in Boston, subject, however, to the differences due to length of intercepting sewers.

Q. Have you enumerated the cities served by the North Metropolitan System?

A. I have, yes, sir.

Q. And giving their population and approximate distances of the outlet?

A. Yes, sir.

Q. From the outfall?

A. Yes, sir.

Cross-examination by Mr. Riker:

Q. Being about to read this table into the record on what facts within your own knowledge is this table based?

A. The table is taken from the records of the Metropolitan Sewerage Commission, I think from the printed report, of Massachusetts. As to my own knowledge I have been familiar in a general way with that system for a great many years, and know that the cities mentioned are served by that system, not from personal examination, but from general knowledge of the subject.

Q. That is the list of the communities that are served by this particular sewer?

A. Yes, sir.

Q. The estimated population, on what is that based?

A. That is taken from the Metropolitan Sewerage Commissioners' Report.

Q. That is an estimate made by them?

A. Yes.

Q. Which you accept?

A. Yes.

Q. You have not verified it?

A. I have not verified it.

Q. And the third column, distance from outlet at Deer Island, where did you get that?

A. I took that off the map, measured it up.

Q. Approximated it?

A. Just approximated it, yes, sir.

Mr. Riker: The reading of this table is objected to on the ground that it is immaterial and does not seem to bear on the question at issue in this case.

2128 The Commissioner: Note the objection of Counsel for defendants.

Mr. O'Sullivan: Taking into consideration the character of the communities to be served by the Passaic Valley Trunk Sewer, and comparing them with those of the North Metropolitan Sewerage District of Boston, did you make any estimate, and if so, state what?

The Witness: I have.

Mr. Riker: One moment, I beg pardon. This is an expert opinion I take it?

Mr. O'Sullivan: An estimate comparing two similar sets of communities.

Mr. Riker: I would like to ask some questions upon the basis of his estimate.

Cross-examination by Mr. Riker:

Q. What knowledge have you of the communities which have contracted to build the proposed sewer in the Passaic Valley Sewerage District?

A. I have the information which I obtained from the printed report of 1908, as to what communities are connected and I have that from my general knowledge as to the character of the communities and the character of sewage, which would be likely to be produced by them.

Q. Do you know what municipalities have entered into the contract?

A. I do not, sir.

Q. How can you tell then as to what the character of the municipalities is which have entered into this contract?

A. I have based by estimates upon the communities mentioned in the report.

Q. What knowledge have you of the character of the City of Newark?

A. Simply that gained from my work there.

Q. How many visits have you made there?

A. I do not know.

Q. Many?

A. Several.

2129 Q. Many?

A. Not a great many.

Q. How many visits have you made to Paterson?

A. A number, I think possibly two or three.

Q. Passaic?

A. About the same number.

Q. Harrison?

A. I have been through Harrison oftener on the train.

Q. In the railroad train?

A. Yes.

Q. How much of a study have you made of the conditions in Harrison?

A. No detailed study.

Q. What is the relative manufacturing industry in Harrison as compared with any of the municipalities in the North Metropolitan Sewerage District?

A. Why, I think Harrison would compare in a general way with the large cities in the North Metropolitan District, such as Boston, and Cambridge and Chelsea.

Q. Why do you say it would compare; do you mean to say it is similar to them?

A. In a general way. Of course no two cities are closely similar, but they are industrial centers, and you would expect trade wastes to be discharged into the sewers from them.

Q. Do you know whether as a matter of fact that is the condition in Harrison?

A. I judge it is from what I know of the community.

Q. Now, just what do you know as a fact that induces you to testify that way?

A. I do not know that I have any particular fact, just a general knowledge.

Q. Not any more than an ordinary observer, have you?

A. I presume not.

Mr. Riker: I object to the reading of this table into the record on the ground that it is not based upon any expert or other knowledge on the part of the witness.

The Commissioner: Note the objection of Counsel for Defendants.

2130 Redirect examination by Mr. O'Sullivan (resumed):

Q. State the contents of that table, Mr. Eddy?

A. That table is as follows:

TABLE 12.

List of Cities and Towns in the Massachusetts North Metropolitan Sewerage District.

Community.	Total population (estimated as of Dec. 31, '10).	Approximate distance from outlet at Deer Is.
(1)	(2)	(1)
Boston (Deer Is.)	1,347	1.1
Winthrop	10,480	2.9
Boston (East Boston)	59,840	5.8
Chelsea	33,090	6.1
Revere	18,870	6.4
Everett	34,310	7.5
Malden	45,260	9.4
Boston (Charlestown)	41,820	9.5
Somerville	78,500	9.5
Medford	23,720	10.3
Melrose	15,930	11.3
Cambridge	105,920	12.4
Arlington	11,490	12.3
Winchester	9,480	14.5
Belmont	5,720	14.5
*Lexington	4,140	15.7
Woburn	15,470	16.6
Stoneham	7,250	17.4
Wakefield	11,580	19.9

* Lexington not connected.

At 1 P. M. adjourned for Noon recess until 2 P. M.

2131 Afternoon Session.

CORPORATION COUNSEL'S OFFICE,
June 17th, 1912—2 p. m.

HARRISON P. EDDY, a witness called on behalf of the Complainants, recalled for further examination testified as follows:

Direct examination by Mr. O'Sullivan (resumed):

Q. Proceed, Mr. Eddy, where you left off before recess?

A. I prepared Table No. 13 in which I give an estimate of the composition of the Passaic Valley sewage in grams per capita and in parts per million, assuming that the quantity of sewage on the average will be 125 gallons per day.

Q. Per capita per day?

A. Per capita per day. I have no extra copy of this table. Shall I read it.

Cross-examination by Mr. Riker:

Q. Is this table which you are about to read based upon observations made by you personally?

A. Yes, sir; observations of the character of the sewage in various places.

Q. Do you mean by that that you are basing it upon the character of the sewage?

A. I am basing it upon my acquaintance with the character of the sewage in various places, as I have noticed for the past fifteen or twenty years, a large number of places.

Q. Now, take the residue on evaporation, suspended matter, where did you get the figures that are included in this table?

A. They are my estimate of the suspended matter which will be contained by the sewage of the Passaic Valley project, if carried out.

Q. And in making that estimate, what assumptions have you made?

A. The only assumption that I have made is that the quantity of sewage will be 125 gallons per capita, and that is my estimate.

Q. Does the residue on evaporation in sewage vary.

2132 A. It does.

Q. In reaching your estimate, have not you assumed something with reference to the character of the sewage in addition to the amount per capita?

A. I think not.

Q. In making your estimate of loss on ignition, on what was that based?

A. On my judgment.

Q. Your judgment acting on what?

A. On the information that I have collected during the last fifteen or twenty years in dealing with such subjects.

Q. And assuming with reference to the Passaic Valley project what?

A. That the flow per capita would be 125 gallons per day.

Q. And of the same general character as you have observed on these other observations that you have made during 15 or 20 years?

A. As represented by them in general; yes, sir.

Q. And upon the subject of variation as to the sewage, is it a combined sewage system or is it a separate system?

A. I have taken that into consideration; yes sir.

Q. What have you considered in this case?

A. That the sewage would be made up from cities having the combined system, and from cities and communities having the separate system.

Q. Where did you get your data upon which you determined this estimate with reference to the Passaic Valley project?

A. So far as the Passaic Valley project is concerned, it represents my judgment, and is not based upon data relating to the sewage from the Passaic Valley District.

Q. There is a factor then in your estimate which is a hypothesis, pure and simple?

A. It is a matter of judgment. I do not know whether that would be called a hypothesis or not. I should hardly think so.

Q. You prefer to call it a matter of judgment anyway?

2133 A. Yes, sir.

Q. It is nothing that has been obtained by an actual investigation of the sewage in question?

A. No, sir. I have made no analyses of the sewage in question.

Q. And this, I suppose, is also based upon the municipalties named in the report of the commissioners in 1908?

A. Yes, sir.

Q. And is not based upon any subsequent fact as to what municipalties are actually engaged in this enterprise?

A. I have no knowledge on that subject.

Mr. Riker: I object to the reading of this table into the record on the ground that it is hypothetical, not based upon facts within the knowledge of this witness, and that it is immaterial.

The Commissioner: Note the objection of Counsel for Defendants.

Direct examination by Mr. O'Sullivan (resumed):

Q. State the contents of the table, Mr. Eddy?

A. The table is as follows:

TABLE 13.

Estimated Average Composition of Passaic Valley Sewage.

	At pumping Sta.		At outlet at Robbins Reef	
	Grams per capita.	Parts per million.	Grams per capita.	Parts per million.
Residue on Evaporation,				
Suspended Matter:				
Total	120	254	80	169
Loss on Ignition	90	191	60	127
Fixed Solids	30	63	20	32
Free Ammonia	8	16.9	10	21
Organic Nitrogen	7.5	15.9	4	8.4
Oxygen Consumed, Total	35	74	23	49

NOTE.—Grams per capita transformed to parts per million on basis of 125 gallons of sewage per capita per day.

2134 Q. How old did you estimate the Passaic Valley sewage will be when it reaches the sedimentation tanks?

A. From 12 to 24 hours old.

Q. You do not then assume that it would influence the condition of the sewage itself?

A. This time will be sufficient for the initiation of septic conditions during warm weather, and possibly also during cold weather. While the sewage if collected from the small lateral sewers may, at times, contain dissolved oxygen, it is probable that the sewage delivered to the sedimentation basins will be almost universally devoid of dissolved oxygen. As bearing upon the quantity of dissolved oxygen likely to be present in the sewage may be mentioned the use of the analyses of sewage made at the Sanitary Research Laboratory of the Massachusetts Institute of Technology and published in Volume 4 of the publication of this Laboratory. The results of these analyses are given in Table 14.

Q. Did that table influence your opinion in this matter?

A. I took that into consideration together with my general knowledge of the character of the sewage. I did not place great dependence on this particular table. I have a copy of that table; on the same sheet is a table of the analysis of the sewage of the City of Gloversville, New York, to which I have not previously referred, and also a note relating to the sewage of the City of Columbus, Ohio, taken from the report of the sewage experiment station, page 36.

Cross-examination by Mr. Riker:

Q. Where did you get the figures that are in this table?

A. The figures in the first part of the table were taken from Column 4 of the Sanitary Research Laboratory Report of the Massachusetts Institute of Technology. The Gloversville figures are taken from the report which was prepared by Mr. Vrooman, City Engineer and myself, as the result of our studies at Glovers-
2135 ville. The note at the bottom of the page was taken from page 36 of the report of Mr. George S. Johnson, on the work of the experiment station at Columbus, Ohio.

Q. Well, the table as to which you say that you have participated in the preparation of, what part did you have in that?

A. I was Consulting Engineer on that work. Laid out the experiments; was in frequent conference with the man in charge of the laboratory, and received weekly or monthly reports—I do not remember which—of the work done at the station, and made my tests from time to time as these reports came in, and I prepared the report in collaboration with Mr. Vrooman, from which the figures are taken.

Q. You were then concerned in the assembling of them and the forming of conclusions?

A. Yes, sir.

Q. That is all you have done with them?

A. I directed the preparation of them.

Q. Do you know of your own knowledge whether your directions were followed out?

A. I believe they were.

Q. I asked you whether you knew?

A. To the best of my knowledge they were.

Q. How much do you know about it?

A. I followed them from month to month, went up there and saw the work going on; had frequent conferences with the man who actually made the analyses; observed the sewage, made a final report in which I analyzed the figures; drew the conclusions from the analyses and designed the plant as based upon them.

Q. Take the first table that you say you took from the volume of reports. What conditions which are involved in this scheme correspond to the conditions which will exist in the Passaic Valley Sewage District?

A. I think practically all are in a general way similar, with the exception that there are rather larger volumes of salt water admitted to the Boston sewer system, which tends to increase the oxygen in the sewage. The Boston Sewer System is somewhat
2136 shorter and the time consumed is probably less than will be the case if the Passaic Valley project is carried out.

Mr. Riker: I object to the reading of these tables into the record, as to the first one because the figures are not proved in a way that renders them competent for use in this case, and as to the second table that the figures are not proved to be within the knowledge of this witness and therefore not competent to be used, and third that it is merely the conclusion of this witness upon facts that are not in evidence in this case and that the tables are immaterial and irrelevant.

The Commissioner: Note the objection of counsel for defendants.

By Mr. Riker:

Q. This table with reference to Columbus, Ohio; where did you get that report?

A. From the report of the sewage experiment station, page 36.

Q. Published by whom?

A. Published by the City of Columbus.

Q. You have no way of knowing whether the figures are correct or not?

A. No sir, except I took them from the report.

Q. You did nothing to verify them or attempt to verify them?

A. I did not.

Mr. Riker: I renew my objection to this table on the ground that it is not based upon any facts that the reports upon which it is alleged to be based have not been proved in this case so as to be evidential.

Direct examination by Mr. O'Sullivan (resumed):

Q. State the contents of those tables?

A. The tables are as follows:

2137 TABLE 14.

Dissolved Oxygen, Nitrates and Nitrites in Sewage.

From Vol. IV, Sanitary Research Laboratory, Mass. Inst. of Technology.

*Boston Sewage.** (*Parts per Million*).

Year.	Nitrates.	Nitrites.	Dissolved oxygen.
1905.			
Oct.-Dec.	0.2	0.1	3.2
1906.			
Jan.-Mar.	0.4	0.0	5.6
Apr.-June	0.3	0.0	2.0
July-Sept.	0.0	0.1	0.2
Oct.-Dec.	0.1	0.0	2.5
1907.			
Jan.-Mar.	0.2	0.1	6.5
Apr.-June	0.0	0.0	3.8

*Considerable quantities of salt water enters sewers at high tide thus bringing in some dissolved oxygen.

*Gloversville, N. Y.** (*Parts per Million*).

(From Report of Vrooman & Eddy.)

Year.	Nitrates.	Nitrites.	Dissolved oxygen.
1908.			
Sept.	0.56	0.22	0.88
Oct.	0.62	0.26	2.15
Nov.	0.62	0.31	1.42
Dec.	0.93	0.29	1.4
1909.			
Jan.	1.13	0.33	2.4
Feb.	1.03	0.44	2.6
Mar.	1.30	0.52	3.6
Apr.	1.68	0.75	3.3
May	1.25	0.63	2.4
June	0.58	0.47	2.0

* Some ster-lization and arrest of Bacterial action due to quality of manufacturing wastes.

2138 Columbus, Ohio.

(*Report of Sewage Exper. Sta., p. 36.*)

No Dissolved Oxygen from 10 a. m. to 4 p. m.

Average for Day, 1.1 Parts per Million.

Sewage about 2 hours old.

Month.	Nitrates.	Nitrites.
August	0.1	0.02
September	0.0	0.00
October	0.1	0.00
November	0.1	0.00
December	0.2	0.15
January	0.1	0.14
February	0.3	0.20
March	0.7	0.17
April	0.2	0.09
May	0.3	0.15
June	0.2	0.04

Q. In the tables that you have just read I notice columns devoted to nitrates and nitrites. What do you mean by these terms nitrates and nitrites?

A. The nitrates and nitrites are forms of oxidized nitrogen and may contribute their oxygen to the sewage as the oxygen dissolved in the sewage, is contributed. For that reason the nitrates and nitrites are instructive, and, in a general way, run parallel with the quantity of dissolved oxygen present.

Q. Well, now looking at these analyses does it appear when the maximum quantity of dissolved oxygen was found to be high and when low judging by the nitrites and nitrates?

A. From these analyses it appears that the maximum quantity of dissolved oxygen was found to be high during the period, January to March, 1907, when it averaged 6.5 parts per million. From July to September, however, it was found to be practically absent from the sewage in spite of the fact that this sewage received large quantities of sea water through the storm overflows and leakage, and that the sampling station is relatively near the upper end of the sewer system. The foregoing comment relates to the analyses of the Boston sewage.

In Table 14 will also be found the results of analyses of sewage of Gloversville, New York. Here, also, it will be seen that the
2139 dissolved oxygen was much lower during the comparatively warm weather of September than during the other months of the year. Unfortunately, these analyses were not made during July and August when, undoubtedly, the oxygen had entirely disappeared from the sewage. These analyses are particularly instructive because of the fact that the sewage contains a very large pro-

portion of tannery waste, which is very stable and has a ster-lizing action upon the domestic sewage. In spite of this condition, which was unfavorable to bacterial life, the oxygen was reduced to 0.88 parts in the month of September, 1908.

In Columbus, Ohio, it was found that no dissolved oxygen was present in the sewage from 10 A. M. to 4 P. M. whereas the average for the day was 1.1 parts per million. The sewage at the experiment station was about 2 hours old. The nitrates and nitrites in the Columbus sewage, while always low, practically disappeared during the warmer weather of the summer and the fall.

The bacterial action going on in the sewer systems and in the Passaic Valley sewer will cause the disintegration, or breaking up of the coarser suspended matter in the sewage, and the flow of the sewage through the pumping machinery will cause a still greater comminution of suspended solids, so that the sewage delivered at the settling basins will probably contain a greater proportion of finely divided suspended matter than most sewages.

What is ordinarily termed fresh sewage, the expression meaning sewage taken from short lateral sewers having good velocities has a marked and characteristic odor which may be compared with the odor of sink water, or the odor from a sink drain. After the sewage has undergone further decomposition and putrefaction the odor becomes very strong and extremely offensive. It is probable that the sewage from the Passaic Valley Project will be *so sold* that, at nearly all times, it will be in a putrid condition and will give off very
2140 offensive odors and it is certain that it will be in this condition during the hot weather of the summer season.

The sewage will contain relatively large quantities of fats much of which will be in suspension in the form of small, floating particles, other portions will be carried by the sewage as an emulsion and still a third portion will form films of oil, or grease, upon the surface of the sewage.

The bacterial content of the sewage may be expected to be high because of the long time required for it to reach the outlet. The number of bacteria in sewage varies greatly and is from 1,000,000 per c. c. in relatively fresh sewage to 10 to 20 million per c. c. in a stale, highly putrid sewage.

The natural color of fresh sewage is grayish, which changes to black upon putrefaction and disappearance of dissolved oxygen. During warm weather the color of the Passaic Valley sewage, except when controlled by industrial wastes will undoubtedly be black. The large quantities of coloring matters now discharged into the Passaic River and into sewers tributary to it, make it certain that the sewage will be highly colored by industrial wastes during much of the time.

Q. Have you given study to the stipulation or compact entered into between the United States Government and the Government of the State of New Jersey, the defendants in this cause?

A. I have, yes, sir.

Q. Have you considered the stipulations in that compact?

A. I have.

Q. After such study as you state you have given to that subject, what effect, if any, will the screening and sedimentation as required by the Government contract have upon the character of the sewage?

A. The principal stipulations as to the treatment which the sewage will receive are as follows, and have been taken into consideration in forming my opinion:

Coarse screens to "remove therefrom all large floating matter."

2140½ Grit basins where the "heavy matter therein shall be taken out as far as practicable."

Self-cleaning mechanical screens, clear openings 0.4 inches. Sedimentation Basins 225 feet long, 15 feet deep, capacity of each tank 1,250,000 gallons. Detention period, 1 hour at maximum rate of flow until 1920, and detention period of 1½ hours at average rate of flow in year 1920. Velocity at average flow, 0.5" per sec., velocity at maximum flow, 0.75" per sec.

Scum Boards to retain floating matter.

Device to remove scum and deposits from basins.

Four or more discharge pipes about 100 feet apart, 150 ton, diameter 1 foot; 10 feet apart for discharge outlets to discharge horizontally across tidal current.

Extent dispersion area, 3½ acres.

Q. Where you referred to the heavy matter therein shall be taken out as far as practicable, you were quoting?

A. The last portion is quoted from the contract.

Q. Now, you have described the coarse screens and grit chambers and the stipulations of the contract. What are the results to be expected?

A. The first step in the project for the partial purification of the sewage of the Passaic Valley will consist of passing the sewage through coarse screens. This is a process in common use and will remove from the sewage only the large coarse matter, which will consist chiefly of paper, pieces of cloth, fruit skins like bits of orange peel, sticks and such other large substances as may be brought through the sewers.

The second step will be the passage of the sewage through grit chambers, which can be relied upon to remove a portion of the heavy material such as sand, gravel, cinders, ashes, coal, etc.

The third step will consist of passing the sewage through self-cleaning mechanical screens, which will have clear openings of not over .4 of an inch. These screens will correspond, in a

2141 general way, to those that are frequently used in sewage purification works for the removal of the coarser floating and suspended matters. They will have slightly smaller clear openings than some of the screens which have been used, but much larger clear spaces than screens ordinarily installed for fine screenings of the sewage. Only relatively coarse matter, such as bits of paper, corks, pieces of cloth, fruit skins, etc., will be removed from the sewage by means of these screens. Large quantities of the more finely divided organic matter, such as particles of grease, small fragments of paper, etc., will pass through these screens.

The fourth step in the process of partial purification will consist of passing the sewage through the sedimentation basins, at a velocity not to exceed .5 inch per second, based upon the average flow, until 1920, and .75 inch per second based upon the maximum rate of flow. These tanks are to be provided with scum boards for retaining any floating matter. The results of sedimentation of the sewage in these tanks will vary greatly from time to time. On the average it is not likely that over 35% of the suspended matter of the sewage will be deposited in the tanks. At times their efficiency may be so high that one-half of the suspended matter will be removed, while at other times it is probable that the removal will not amount to more than 5 or 10 per cent.

This opinion is based upon personal experience in the sedimentation of sewage in tanks somewhat similar to those proposed in this case. A prolonged series of tests was made in Worcester, Massachusetts, with a large horizontal flow tank, the velocity of flow ranging, in different experiments, from 8 feet per hour to 27.8 feet per hour. The velocity in the proposed Passaic tanks will range from 150 to 225 feet per hour. The results of the Worcester experiments at the very low velocities mentioned range from 31.7% to 66.3% removal of suspended matter, the average being about 48% removal. (See Tables 15 and 16).

Beginning in September, 1908, a large proportion of the
2142 sewage of the City of Worcester was passed through one of the sedimentation basins before being discharged onto the sand filter beds. The velocity of flow through the basin during this period was 333 feet per hour. The monthly efficiency of sedimentation varied greatly, the maximum being 56.6% while, during several months, the average efficiency was below 30%.

The tanks at Worcester, used for the sedimentation of sewage, were equipped with efficient scum boards, and there is no reason to expect any better results from the Passaic Valley tanks than were obtained with these.

Relatively large quantities of visible suspended matter escaped with the effluent from the Worcester tanks, and this will undoubtedly be true in the case of the Passaic Valley purification works. Furthermore, at seasons of the year when fermentation of the sludge is active, gas is formed in large quantities in the deposit and from time to time great masses of sludge will be carried to the surface of the tanks by the entrained gases. At such times large quantities of sludge are likely to pass over from the tanks with the effluent, and they will ultimately be discharged at Robbins Reef.

The effluent at Worcester contained large quantities of grease in suspension and, upon standing, a film of oil or grease would invariably rise to the surface of the effluent.

Q. Did you prepare any tables to show the matters that you have described as occurring at Worcester under somewhat similar conditions as those proposed for the Passaic Valley Trunk Sewer?

A. I have such tables, upon which I have based my opinion in part. They were not, however, prepared for this case, or recently, being prepared in 1910.

Q. By whom?

A. The first one is a copy of a table appearing in a paper which I read and prepared in collaboration with Mr. Fales, who was chemist, under my direction, and made the actual analyses. That appears in the Report of the Association of Engineering
2143 Societies.

Q. State the contents of that Table No. 15?

Mr. Riker: I object on the ground that it is not a memorandum made at the time or by this witness, and not properly proved so as to be evidence in the case, or to be used by the witness as proven data in the case.

The Commissioner: Note the objection of Counsel for Defendants.

A. Table No. 15 is as follows:

No.	Total gallons treated.	Sewage. (Parts per 100,000.) Total suspended solids.	Sewage. (Parts per 100,000.) Suspended album. ammonia.	Effluents. (Parts per 100,000.) Total suspended solids.	Effluents. (Parts per 100,000.) Suspended album. ammonia.	% Suspended solids removed.	% nitr. alb. ammonia removed.	Rate Mgd.	Period of storage (hour).	Horiz. Vel. ft. per hr.
1	8,250,000	17.9	0.346	11.0	0.241	38.5	30.3	0.3	20.8	8.
2	8,982,500	30.0	.610	18.3	.266	39.0	56.4	0.3	20.8	8.
2a	8,982,500	30.0	.610	20.0	.322	31.7	47.2	0.3	20.8	8.
3	9,000,000	31.9	.656	14.8	.236	53.1	63.9	½ at 0.3	20.8	8.
								½ " 0.4	15.	11.1
4	11,175,000	33.9	.602	17.0	.327	49.8	45.7	0.4	15.	11.1
5	14,065,250	36.1	.656	21.3	.320	41.0	51.2	0.5	12.	13.9
5a	10,479,157	33.3	.518	15.6	.151	53.2	70.7	0.5	12.	13.9
6	13,062,500	36.4	.697	16.0	.333	56.0	52.2	0.6	10.	17.
7	34,908,250	24.6	.333	8.3	.060	66.3	82.0	0.75	8.	20.8
8	28,062,500	28.4	.333	14.3	.167	49.6	49.8	0.75	8.	20.8
9	29,083,125	20.5	.272	10.1	.103	50.7	62.3	0.75	8.	20.8
10	21,312,500	29.1	.503	12.2	.204	58.1	59.4	0.75	8.	20.8
11	15,937,500	26.3	.474	12.5	.181	55.8	61.8	0.75	8.	20.8
12	20,938,333	33.3	.813	19.4	.263	41.7	48.9	1.0	6.	27.8
13	29,369,000	33.5	.640	16.3	.431	51.3	32.6	1.0	6.	27.8

Tanks each 40 feet x 166 2/3 ft. (capacity 350,000 g.a.), divided into four compartments by sludge dams 2 or 3 ft. high. Scum boards directly over dams extending 18 inches below surface and 8 inches above surface. Inlet through trough with apertures 18 inches below surface. Outlet over weir.

2a for tank No. 7, period May 23-June 28, 1902, *c* tank operated as septic tank, but just started, so that is comparable with No. 8 used as sedimentation tank.

3a period, Aug. 17-Sept. 12, 1903, tank No. 8 run at 5 Mgd. rate as septic tank, but during this period was comparable with tank No. 7 used as sedimentation tank.

3a, *3f*, and *3l*, tank No. 7 all, others are tank No. 8.

Sewage Disposal Sedimentation.—Table 15.

2145 Q. Now, the next one?

A. The next one is a table made up of the average results obtained from the analysis of sewage and effluents, entering and leaving the tank in question at Worcester, during part of 1908, 1909 and 1910. That is table No. 16.

Q. State the contents of that table?

Cross-examination by Mr. Riker:

Q. Does this table contain your own observations?

A. I did not make the analyses, no, sir.

Q. Does it contain any facts observed by you personally?

A. I have observed the flow of the sewage through this basin. In fact I built the basin which is tributary to it. I know the local conditions very well.

Q. That is all about this table that is within your own knowledge?

A. I think probably I calculated the percent removed, the last two columns.

Q. Mere mathematical calculation?

A. Mere mathematical calculation. The figures in the first five columns were taken from the record books in Worcester.

Q. You did not keep them, the books?

A. I did not, sir.

Mr. Riker: The reading of this table into the record is objected to for the same reasons as those offered against Table No. 15.

Direct examination by Mr. O'Sullivan (resumed):

Q. State the contents of that table No. 16, Mr. Eddy.

A. The table No. 16 is as follows:

2146 *Worcester, Mass., Experiments of Sedimentation* (1908-1910).

Date.	Sewage. (Parts per 100,000.) Total suspended solids.	Sewage. (Parts per 100,000.) Suspended albumn. ammonia.	Effluent. (Parts per 100,000.) Total suspended solids.	Effluent. (Parts per 100,000.) Suspended albumn. ammonia.	Per cent. suspended solids removed.	Suspended alb. ammonia. removed.
Sept., 1908..	42.8	.937	24.4	.677	43.0	27.8
Oct.	47.0	.896	39.4	.774	16.2	13.6
Nov.	52.0	1,203	31.6	.656	39.3	45.5
Dec.	31.8	.835	13.8	.540	56.6	35.3
Jan., 1909..	34.2	.731	25.2	.551	26.3	24.6
Feb.	29.6	.587	21.0	.360	29.0	38.7
Mar.	27.2	.565	20.4	.428	25.0	24.2
Apr.	29.4	.487	20.0	.299	32.0	38.6
May	34.2	.579	18.8	.408	45.0	29.5
June	33.0	.572	19.0	.462	42.4	19.2
July	39.8	.834	24.4	.512	38.7	39.8
Aug.	43.8	.877	28.4	.550	35.2	37.3
Sept.	41.4	.903	24.2	.550	41.5	39.1
Oct.	41.4	.883	24.8	.521	40.0	41.0
Nov.	47.8	1,029	28.0	.575	41.4	44.1
Dec.	39.0	.960	29.4	.785	24.6	24.5
Jan., 1910..	32.8	.715	26.6	.569	18.9	20.4
Feb.	21.8	.556	22.4	.440	—2.75?	20.9
Mar.....with	April sample.	.513, with	April sample.	.420	....	18.1
Apr.	31.4	.667	23.8	.483	24.2	27.6
May	36.6	.847	25.2	.591	31.1	30.2
June	34.6	.817	23.8	.575	31.2	29.6
July	42.2	.797	27.8	.615	37.1	22.8
Aug.	37.2	.741	27.6	.542	25.8	26.9
Sept.	31.6	.803	23.8	.638	24.7	20.5
Oct.	30.6	.850	30.2	.604	1.3?	29.5
Nov.						
Dec.						

NOTE.—Average rate of flow—16.8 Mgd. allowing for 2 ft. height of sludge dams or 5 ft. depth of tank for flow. The period of storage—0.35 hours and the horizontal velocity—475 ft. per hour. Figuring on total capacity of tank, the period of storage—½ hour and the horizontal velocity 333 feet per hour.

NOTE.—Tanks Nos. 7 and 8 each 40 feet wide x 166 2/3 ft. long x 7 feet deep.

Sewage Disposal Sedimentation.—Table 16.

2147 Q. Were the chemical determinations made by the chemist under your direction at the time?

A. On Table 16 they were not. On Table 15 they were, the chemist being under my direction, the experiments being conducted practically under my observation. I think I saw the plant and that part of the plant as often as three or four times each week during that period.

Q. As to the maximum proportion of sewage to harbor water, in the vicinity of outlets, what study did you give to that phase of the subject?

A. Obviously, it is not possible to state with accuracy what proportion of sewage will be present in any given proportion of water in the vicinity of Robbins Reef because this depends upon such a multitude of variable conditions. It may be helpful, however, in forming an opinion as to conditions in the vicinity of the outlets, to assume, for the time being, that the sewage will be uniformly mixed with the

water passing over the dispersion area, and that a ribbon, or stream of mixed sewage and water will exist in the harbor. This stream will flow backward and forward with the tides and the velocity of the flow will govern, to some extent, the quantity of water passing over the outlets.

From certain diagrams, furnished by the Metropolitan Sewage Commission, Figs. 3 and 4, it will be seen that the velocity of currents in the vicinity of Robbins Reef falls at time- to 0 and is as low as .4 or .5 feet per second for considerable periods of time, as, for example, 2 hours. As will be expected there is some variation in the velocity of flow at different depths but a reasonable assumption would seem to be an average rate of flow of .4 ft. per second for a period of two hours. This assumption, of course, takes into consideration the fact that the tide moves in one direction half of the time and in the opposite direction half of the time.

Mr. Riker: I object to further testimony in answer to a question which is not limited in such a way as not to cover such a broad matter
that it is impossible to say what is relevant or irrelevant mat-
2148 ter that may be injected into the case in answer to that type of question. It should be made more specific.

The Commissioner: Note the objection of Counsel for Defendants.

Q. Proceed, Mr. Eddy?

A. Upon this assumption the quantity of harbor water passing over the outlets will be about 8,160 cubic feet per second assuming that the outlets are distributed over a length of 510 feet and are 40 feet below the surface of the water. The rate of discharge of sewage, using the maximum provided for by the Passaic Valley Sewerage Commission, will be 557 cubic feet per second. It follows, therefore, that the water passing over the outlets will contain 557 parts of sewage in 8,160 parts of mixture of sewage and harbor water, which is equivalent to 1 part to 13.4 parts of harbor water.

Obviously, this is a very rough approximation of the proportions of sewage to harbor water as it is not possible to conceive that the ribbon of water passing over the outlets will retain its shape and proportions and will return without the mixture of other water from the harbor. It is conceivable, however, that under some conditions the proportion of sewage in the harbor will be as great as 1 part sewage to 13 parts of water, assuming for the time being that the original water contained no sewage and that this mixture resulted from a single trip over the outlets, and it is also possible to conceive that if this water returns over the outlets, the proportion of sewage will be greatly increased and may possibly reach toward 1 part sewage to 6 parts of water.

The foregoing calculations are based on the assumption that the sewage will be thoroughly diffused through the water passing over the outlets, which does not seem possible to realize. If, as seems
certain, a large proportion of the sewage will make its way
2149 well toward the surface of the water, it is conceivable that the proportion of sewage in the surface waters may even exceed

the figures here given, under conditions which favor the concentration of the sewage in the immediate vicinity of the outlets.

Q. Did you prepare a table showing the data on currents which guided you in making your computations?

A. I have, yes, sir, Table No. 17. That is made up, from the diagram to which I referred as having been furnished by the Metropolitan Sewage Commission of New York through your office.

Q. Mr. Eddy, how did you prepare this date on currents as set forth in Table No. 17?

A. I took it off of diagram furnished by you and prepared as I understand, by the Metropolitan Sewage Commission of New York.

Q. Have you got those diagrams?

A. I have. The originals and the copies. I can give you the originals if you prefer. The copies I have re-drafted in my office.

Q. And you compared them with the originals?

A. Yes, sir.

Q. How did you find them on comparison.

A. They were traced from the originals and they are a correct copy, within reasonable limits of accuracy of drafting.

Cross-examination by Mr. Riker:

Q. Mr. Eddy, this table which I think is marked Table No. 17, is an expression in figures of the contents of the diagrams which you said were furnished to you by the Metropolitan Sewerage Commission?

A. I think actually by Dr. O'Sullivan, but they bear the marks of the commission.

Q. You have no knowledge in regard to the data which were furnished to you through Dr. O'Sullivan's office?

A. No, sir.

Q. You do not know whether that is correct or not?

A. I do not.

Q. Or whether it is a graphic illustration or embodiment of any fact or figures?

A. I do not.

Q. And this table is what; is it correctly described by me
2150 as a representation in figures of the graphic illustration on these two pamphlets or diagrams?

A. It is, yes, sir.

Q. It contains nothing more?

A. No, sir.

Mr. Riker: I object to it on the ground that it is based on something that has not yet been proved to represent any fact and therefore does not itself represent any fact proved in this case.

The Commissioner: Note the objection of Counsel for Defendants.

Direct examination by Mr. O'Sullivan (resumed):

Q. State the contents of Table No. 17, Mr. Eddy.

A. Table No. 17 is as follows:

2151 TABLE 17.

Data on Currents.

Derived from the Accompanying Blue Prints Prepared by the Metropolitan Sewerage Commission.

Mean Velocity of Currents, in Feet per Second, Observed Near Proposed Outlet, Passaic Valley Sewer. August 23 to Dec. 10, 1909 (Near Time of Neap Tides).

Stage of tide.	Depth. 4 feet.	20 feet.	40 feet.	Average.
Flood	0.8	1.05	0.95	.94
Ebb	1.31	1.31	1.11	1.25

Near Time of Spring Tides.

(Velocity in feet per second.)

Stage of tide.	Depth. 4 feet.	20 feet.	40 feet.	Average.
Flood	1.97	1.52	1.50	1.66
Ebb	2.13	2.05	1.92	2.04

Maximum and Minimum Currents.

(Feet per second.)

At Time of Neap Tides.

Stage of tide.	Depth. 4 feet.	20 feet.	40 feet.
Maximum on—			
Flood Tide	1.3	2.1	1.9
Ebb Tide	2.3	2.5	2.2
Minimum on—			
Slack H. W.	0.4	0.3	0.2
Slack L. W.	0.4	0.4	0.0

At Time of Spring Tides.

Stage of tide.	Depth. 4 feet.	20 5eet.	40 feet.
Maximum on—			
Flood Tide	3.3	2.8	2.6
Ebb Tide	3.7	3.8	3.5
Minimum on—			
Slack H. W.	0.6	0.4	0.6
Slack L. W.	0.8	0.5	0.3

2152 Mr. O'Sullivan: I offer the chart produced by this witness labeled "Velocities observed at proposed outlet of Passaic Valley Sewer near the time of neap tides", which chart is marked with the figure "3". I offer it in evidence and ask that it be marked Complainants' Exhibit No. 130 in evidence.

Cross-examination by Mr. Riker:

Q. Mr. Eddy, I have asked you about that; you have no knowledge at all except it was furnished by Dr. O'Sullivan?
A. I ought to add perhaps that that is a copy which I made of the blue print which he sent me.
Q. Then this is a copy of a diagram of which you had no personal knowledge except that it came from Dr. O'Sullivan?
A. Yes.

Mr. Riker: I object to the offer on the ground that it has not been properly proved.
The Commissioner: Note the objection of Counsel for Defendants. Received and marked Complainants' Exhibit No. 130.
Marked Complainants' Exhibit No. 130.
Mr. O'Sullivan: I offer the chart showing the "Velocities observed at Proposed Outlet of the Passaic Valley Sewer near the time of spring tides" said chart being indicated by the Figure 4. I offer this in evidence and ask that it be marked Complainants' Exhibit No. 131 in evidence.

Cross-examination by Mr. Riker:

Q. Mr. Eddy, this is a blue print copy of a paper furnished you by Dr. O'Sullivan?
A. Yes, sir.
Q. Did you make the tracing?
A. I did not. It was made under my direction.
Q. Did you compare it?
A. I did.
Q. It was correct?
A. Yes, sir.

2153 Q. Have you compared the blue print with the original tracing?
A. Yes, I made up the table from the blue print and compared that with the original diagram furnished me.
Q. And the original that you made the tracing from, where did you get that from?
A. It was furnished me by Dr. O'Sullivan.
Q. What did you do with it?
A. I have it here, sir.
Q. Have you any knowledge as to whether or not the original represents any actual fact?
A. I have no knowledge.

Mr. Riker: I object to the offer on the ground first, that the original, if produced, and offered, would be incompetent, not having

been proved in the case. Secondly, it appears that the original is here and can be offered, and that this is a mere blue print of an original, which is under the control of Complainants' Counsel.

The Commissioner: Note the objection of Counsel for Defendants. Received and marked Complainants' Exhibit No. 131.

Marked Complainants' Exhibit No. 131.

Direct examination by Mr. O'Sullivan (resumed):

Q. Now, Mr. Eddy, has the sewage a tendency to rise on the surface of our harbor waters?

A. It has.

Q. Why.

A. Because it is lighter in weight and usually warmer in temperature.

Q. State what the relative specific gravities and the other factors that would give that buoyancy are?

A. Sewage is much lighter than sea water, the relative specific gravity of the two being approximately 1.0018 and 1.025 respectively. This specific gravity of sewage was determined by test of a sample of sewage taken from the North Metropolitan sewer. The sewage contained over 1.022 parts of chlorine per million and, consequently, the specific gravity was higher than that of the Passaic Valley sewage is likely to be. The specific gravity of sea water given is that containing substantially no land water. As the proportion of land water to sea water is increased the specific gravity of the
2154 mixture is reduced so that a mixture of 30% land water and 70% sea water will have a specific gravity of approximately 1.017. During much of the time the temperature of the sewage will be higher than the temperature of the harbor water which will increase the difference in their respective specific gravities.

From Table 18, which has been checked by recent observation, it appears that the specific gravity of seawater containing 35% land water and having a temperature of 77°F. will be 1.0140 which is much heavier than sewage even at a temperature of 60°F., said specific gravity being 1.0018.

Q. Who prepared Table No. 18?

A. That table was prepared under my direction, by my assistant. It was made up of computations and checked with various data, which is in published form. I had the actual determinations of the specific gravity made in Mr. Western's laboratory, which adjoins our office and under my supervision. In fact, several, if not all of them were under my actual observation.

Q. I see in the first two columns of that table No. 18, under the word "Temperature" the two letters—C for the first column and F for the second column; what do these two letters signify?

A. C stands for centigrade and F for Fahrenheit.

Q. State the contents of that table No. 18?

Cross-examination by Mr. Riker:

Q. Were these figures obtained from actual experiments?

A. The figures in the third column and in the ninth column were obtained from actual experiments.

Q. And the other columns?
A. They are interpolated.
Q. Calculated?
A. Yes, sir, from the other two.
Q. Percentages, are they not?
A. Practically that. They are proportional parts.
Q. Now, taking the figures in the third column, did you take actual sea water?
A. Yes, sir.
2155 Q. Where did you get it?
A. Off Revere Beach from a pier extending out into the salt water.
Q. Where?
A. Revere Beach, in Boston.
Q. Who took the samples?
A. A Mr. Watson.
Q. Were you there?
A. I was not.
Q. After the samples were taken, what was done with it?
A. He brought it to the laboratory. It was there tested.
Q. By whom?
A. By Mr. Gamage.
Q. Did you have anything to do with that?
A. I observed the taking of the specific gravity.
Q. In how many cases?
A. In several. I could not say that I was present when every one was taken.
Q. Under what conditions was the specific gravity of these samples obtained or taken?
A. Under the usual laboratory conditions.
Q. With reference to temperature?
A. The temperature was taken.
Q. At what temperature?
A. The specific gravities were taken at temperatures indicated 0 Centigrade, 5, 10, 15, 20 and 25.
Q. And you say that you observed some of the determinations of the specific gravities?
A. Yes, sir.
Q. You cannot state which?
A. I cannot state with accuracy, no, sir.
Q. Now the ninth column contains land water?
A. Yes, sir.
Q. 100 per cent?
A. Yes, sir.
Q. Where were the samples obtained?
A. That was taken from the tap in the laboratory.
Q. Did you take it?
A. I saw it taken.
Q. Did you determine yourself the specific gravity of the water at the different temperatures?

A. I saw that taken and determined in the same way.

2156 Q. All of them?

A. I think not, no, sir.

Q. Did you make the calculations of the proportions intervening between the sea water and the land water?

A. No, sir, those were made by my assistant.

Mr. Riker: The reading of this table into the record is objected to on the ground that this witness is not competent to testify as to the figures, not having made the determinations himself and for a considerable part not having been made under his observation.

The Commissioner: Note the objection of Counsel for Defendants.

Direct examination by Mr. O'Sullivan (resumed):

Q. State the contents of that Table No. 18?

A. Table No. 18 is as follows:

TABLE 18.

Specific Gravity (Determined by Experiment of Various Mixtures of Sea Water and Land Water (Distilled) at Different Temperatures).

(Sea Water Used at 60° F. Had Specific Gravity of 1.0243 Chlorine 18,750 Parts per Million).

Temperature.		Percent. Land Water.						
C.	F.	0	15	25	35	50	75	100
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
0	32.....	1.0257	1.0221	1.0195	1.0171	1.0132	1.0070	1.0008
5	41.....	1.0255	1.0219	1.0193	1.0169	1.0133	1.0071	1.0010
10	50.....	1.0249	1.0214	1.0188	1.0164	1.0128	1.0067	1.0007
15	59.....	1.0243	1.0208	1.0183	1.0158	1.0122	1.0061	1.0001
20	68.....	1.0234	1.0198	1.0173	1.0150	1.0114	1.0052	.9991
25	77.....	1.0224	1.0188	1.0162	1.0140	1.0103	1.0042	.9980
—	—	—	—	—	—	—	—	—
15.6	60.....	1.0243	1.0207	1.0182	1.0159	1.0123	1.0061	1.0000
4	39.6...	1.0256	1.0220	1.0194	1.0170	1.0134	1.0071	1.0009

NOTE.—Hydrometer reads 1.0000 at 60° F. distilled water, and this is used as standard for reference.

2157 Q. While we are on this subject of temperature, Mr. Eddy, did you take the mean monthly temperature of sewage of any cities, and if so, state what cities?

A. I have compiled a table of the mean monthly temperatures of sewage in the City of Gloversville, New York, Lawrence, Massachusetts, Columbus, Ohio, Waterbury, Connecticut. This is known as Table No. 19.

Cross-examination by Mr. Riker:

Q. These are mean temperatures you say?

A. Yes, sir, average temperatures.

Q. By the month?

A. Yes, sir.
Q. How many determinations were made for the figures under January at Gloversville?
A. The entire day, I think.
Q. And the same for every month?
A. The same for each month, yes, sir.
Q. What year is this?
A. In Gloversville, 1908 and 1909.
Q. The years are indicated at the bottom of the table, I see?
A. I think they are, yes, sir.
Q. And where were the samples taken in the Gloversville sewage?
A. At the experiment station at the mouth of the intercepting sewer.
Q. How long was that intercepting sewer?
A. From its mouth to the upper end I think about 3 miles.
Q. At what depth below the surface of the water?
A. It varies. I should say the maximum was about 15 feet and the minimum probably 6 feet.
Q. Did this sewage contain a large amount of manufacturing waste?
A. It did, yes, sir.
Q. Does the length of the discharge outlet and the depth at which it is laid, have any influence upon the temperature of the sewage discharge?
A. It might have a relatively small influence.
Q. Depending upon the length of the discharge and the depth at which it was laid?
A. Yes, sir.
2158 Q. Varying according to some extent?
A. Varying accordingly but not proportionately.
Q. I did not say proportionately. The Lawrence determinations, are they based on daily samplings?
A. I think so, yes, sir.
Q. Did you take the sample?
A. I did not.
Q. Did you in any of these cases?
A. I did not.
Q. Did you take the temperatures in any of the cases?
A. No, sir.
Q. How do you know they are correct?
A. I have taken them from the published reports.
Q. In what reports do these temperatures appear?
A. The Gloversville temperatures are given in the report by Mr. Vrooman and myself, the Lawrence, Massachusetts temperatures taken from the state Board of Health reports. The Columbus, Ohio temperatures were taken from the report of the work of the experiment station at Columbus, Ohio, and the Waterbury temperatures, I think, came to me by personal letter from Mr. Taylor.
Q. Do you know where the Lawrence samples were taken?
A. They were taken at Lawrence at the experiment station.
Q. How far is that from the outlet?

A. It is the outlet.
Q. How long is the intercepting sewer in that case?
A. I do not think there is an intercepting sewer.
Q. This is then a point of collection of the sewage system?
A. It is taken from one of the main trunk sewers, not intercepting sewers.
Q. Taken from one of the municipal sewers?
A. That is true, yes, sir.
Q. And at what depth?
A. I should say about 15 feet, from memory.
Q. Where were the Columbus samples taken?
A. At the experiment station.
2159 Q. Where is that with reference to the system?
A. I do not know. I never saw that station.
Q. The Waterbury figures, where were they taken?
A. At the experiment station.
Q. Where is that with reference to the system?
A. I do not know.
Q. And Gloversville, you have testified to those?
A. That was at the experiment station.
Q. You do not know as to the correctness of any of these figures from your own personal observations?
A. I do not know of the actual correctness of the observation.

Mr. Riker: I object to the reading of these figures into the record on the ground that they are not within the knowledge of this witness, and also on the ground that they appear, so far as this witness is able to testify, to be taken under conditions which are different from those which will prevail in the Passaic Valley Sewerage District.

The Commissioner: Note the objection of Counsel for Defendants.

Direct examination by Mr. O'Sullivan (resumed).

Q. State the contents of Table No. 19, Mr. Eddy?
A. Table No. 19 is as follows:

2160 TABLE 19.

Temperature of Sewage Arranged by Months.

	Glovers.	Lawrence.	Columbus.		Waterburg.	Avg. not including Gloversville.
January	47	51	52		50	51
February	46	48	48		50	49
March	45	47	50		49	49
April	46	54	58		52	55
May	51	58	61		60	60
June	57	66	66		61	64
July	59	68	..		65	66
August	63	71	69	(16 d'ys)	72	71
September	62	66	70		73	70
October	57	64	65		66	65
November	52	59	61		52	57
December	49	48	53		50	50
	53	58	59		58	59

Gloversville, N. Y. 1908-1909
Lawrence, Mass. 1906-1907
Columbus, Ohio 1904-1905
Waterbury, Conn. 1905-1906

Q. Mr. Eddy, from Table No. 19 that you have just read, relative to the temperature of sewage, arranged by months, for the cities you have just enumerated, what deduction do you draw from the study of that table as applied to the Passaic Valley Trunk Sewer Project.

Mr. Riker: The question is objected to on the ground that it appears that the testimony given by this witness is that the conditions are not similar, and that therefore, no comparison can be made which is of any value in this case, or evidential in this case.

The Commissioner: Note the objection of Counsel for
2161 Defendants.

A. Taking into consideration the figures given in Table No. 19 and my experience with temperatures of sewage in general at the location of the outlet, it is my opinion, that the temperature of the sewage as discharged at Robbins Reef will be higher than 60 degrees Fahrenheit, during July and August, and probably will be in the vicinity of 70 degrees Fahrenheit. It seems evident, therefore, that with the great difference between the specific gravity of sewage at 60 degrees and of harbor water, containing 30 per cent.

land water, at 77 degrees, the sewage will during the summer months have a decided tendency to rise to the surface.

In connection with the large number of determinations of dissolved oxygen, the proportion of land and sea water in the harbor at the sampling points has been determined, by the Metropolitan Sewerage Commission of New York. From this examination it appears that during the summer time a fair assumption is that the harbor water at Robbins Reef is made up of about 70 per cent. seawater and 30% land water, as assumed above.

Mr. Riker: I want to ask that there be inserted there a notice of motion to strike out the testimony of this witness as to what has been proved in this case with reference to the proportion of land and sea water in the harbor, as not being proper testimony for him to give.

The Commissioner: Note the objection of Counsel for Defendants.

Q. Proceed, Mr. Eddy?

A. This is well illustrated by the diagram on page 523, 1910 Report Metropolitan Sewerage Commission which shows that during the year, from about the first of July to the last of December, the water consisted of about 20% land water and 80% sea water.

Mr. Riker: I desire to have notice of motion noted to strike out the testimony as to the contents of a document not in evi-
2162 dence in this case as being hearsay.

The Commissioner: Note the objection of Counsel for Defendants.

Q. Proceed, Mr. Eddy?

A. In addition to the tendency of the sewage to rise to the surface, caused by the differences between the specific gravity of the sewage and of the sea water, there is an important fact that the sewage as discharged from orifices, or outlets at the bottom of the harbor will leave the pipe openings with an initial velocity of 2.35 1 feet per second, assuming the maximum rate of flow provided for by the Commission. This initial velocity will have an important effect in causing the sewage to rise to the surface of the harbor.

Q. What did you base your calculation of the velocity on?

A. That was based on the Government stipulation of 150 Tees with openings at right angles, each outlet having a diameter of 1 foot.

Q. Have you taken into consideration in your studies, Mr. Eddy, the movements of sewage fields?

A. I have.

Q. State with what results?

Mr. Riker: I object to the question on the ground that the witness' attention has not been drawn specifically to any sewage field, or any evidence in the case with reference to sewage field, and unless the question is made more specific, Counsel for Defendants cannot have any light upon the direction that the evidence is likely to take, and therefore will not be able to object properly to the evidence elicited by the question.

The Commissioner: Note the objection of Counsel for Defendants.

Q. Applying, Mr. Eddy, such studies as you have made of sewage fields to the probable discharge of sewage at the outfall
2163 near Robbins Reef of the Passaic Valley Trunk Sewer?

A. It seems certain that under some conditions a sewage field will form in the vicinity of the outlets at Robbins Reef. This field will be indicated by an increased turbidity of the water, at times by color imparted to the water by the sewage, by an oily sleek, and, under some conditions, by a floating scum consisting, probably, largely of grease. Such a sewage field will be carried in the direction of the tidal currents unless driven in other directions by high winds. The further the field travels from the outlet, the greater will be the tendency towards diffusion of the sewage in the harbor waters and the characteristics of the field will gradually disappear. It will probably first lose its turbidity then its color, afterwards the sleek will disappear and finally the scum will be broken up and scattered so that the field may be said to have completely disappeared.

It is extremely difficult to predict how far such a field will travel because of the great number of varying conditions. Some light may be thrown upon this subject by the float experiments and observations which have been made by the Metropolitan Sewerage Commission of New York. Three of these experiments are described in the Report of the Commission for 1910 as follows:

Float Records in the Upper Bay of at Least Five Hours' Duration.

Mr. Riker: I object to the witness using the Metropolitan Sewerage Commission's Report of 1910 for the reason that it has not been proven as an exhibit in this case, and his evidence therefore is merely hersay evidence.

The Commissioner: Note the objection of Counsel for Defendants.

2164 A. The float of March 5, 1907 drifted from near Robbins Reef to West 54th Street, Manhattan, or 8 miles in 6 hours and 45 minutes.

Float No. 34 drifted from near Robbins Reef to West 60th Street Manhattan or 9.14 miles in 6 hours and 18 minutes.

Float No. 37 drifted from near Robbins Reef to Bank Street, Manhattan, or 6.85 miles in 6 hours and 20 minutes.

From these experiments it is clear that floating matters will travel long distances from the point of starting. It is probable that in most cases a sewage field would be broken up before it had traveled as far as West 54th St. at a point reached by the float set adrift on March 5, 1907. These float experiments, however, emphasize the possibility of sewage matters being carried relatively long distances from the point of discharge.

Q. Mr. Eddy, what function does oxygen play in the purification of organic waste in the harbor waters?

A. The term "purification" as applied to sewage disposal, means the transformation of the unstable organic matter to matter which is more stable and finally to the inorganic and inert compounds nitrates, carbonic oxide and water.

This is one of the well known and inevitable processes of nature and the problem of sewage disposal is to bring about these inevitable changes without causing a nuisance.

Bacteriologists have shown that when these changes take place in the presence of available oxygen the process is one of oxidation with the aid of bacteria that live in the presence of air, and that this transformation is brought about without objectionable conditions. When, however, oxygen is not present in available form, a totally different condition results. A reducing action takes place, the organic matter being broken up by bacteria which live in the absence of air, and many unstable and offensive compounds and gases, such as
2165 hydrogen sulphide, are formed.

Q. What significance has the question relating to the quantity of Oxygen in our harbor waters?

A. A very large number of determinations of the quantity of oxygen dissolved in the waters of the harbor, have been made by the Metropolitan Sewerage Commission of New York, during the years 1909 and 1911.

Q. One moment. I hand you Complainants' Exhibit No. 94 and ask if that contains determinations that you have just stated were made by the Metropolitan Sewerage Commission in the year 1911?

A. It appears to, yes sir.

Q. I hand you Complainants' Exhibit No. 31 and ask you if that contains the oxygen determinations made by the Metropolitan Sewerage Commission to which you have alluded as having been made in the year 1909?

A. It does.

Q. Have you studied both sets of those tabulations for these two years?

A. I have.

Q. State what you found relative to those determinations and their usefulness in your studies?

A. These determinations are particularly useful in showing to what extent the supply of oxygen dissolved in the harbor has been depleted, either directly or indirectly, by the sewage discharged into these waters.

Land water when saturated with oxygen, or, as usually expressed, when the water is 100% saturated, contains about 6.5 c. c of oxygen per liter of water. Fully saturated sea water at the same temperature, contains about 5.3 c. c. of oxygen per liter. Fresh sewage may contain a substantial quantity of oxygen, especially in cold weather when biological processes have not become active. As the sewage increases in age and particularly in hot weather, the development of organisms in it is so rapid that its supply of dissolved oxygen is very quickly exhausted. If the sewage is mixed with water,
2166 water, either land water or sea water, which contains dissolved oxygen, it (that is the dissolved oxygen) is imme-

diately utilized by the biological processes and the quantity is gradually depleted until it is exhausted, provided the proportion of sewage in the admixture is sufficiently great. This action is constantly going on in the waters of New York Harbor, which receive large quantities of sewage.

The quantity of dissolved oxygen contained in any given admixture of sewage and water, may therefore be taken as an index, to the quantity of pollution and the existing or past conditions as to germ life. For example, the waters of Newtown Creek receive large quantities of sewage, and the supply of dissolved oxygen is more or less depleted, in the upper portions, which are not supplied with great quantities of fresh water, the supply of oxygen being entirely exhausted much of the time. At or near the mouth of the creek, where there is a greater dilution of the sewage and more opportunity for a change of water in the creek, from day to day, there is considerable oxygen present at times. An observation of these waters indicates a difference in condition between the waters at the mouth and the waters further up the creek. On July 13, 1911, the water at the mouth of the creek was dark in color and offensive odors were given off from it. It apparently contained very little dissolved oxygen. On October 19, 1911, the condition of the water at the mouth of the creek was not as bad as on July 13, and it was apparent that the water contained dissolved oxygen. There was, however, a distinct odor of sewage given off from the water, which odor gradually increased as one proceeded up the creek, until the creek water became black and very offensive.

Q. Are you talking now of those exhibits that I called your attention to?

A. Yes, sir, I took these from the exhibit.

Adjourned to June 18, 1912 at 10:30 A. M.

2167 Supreme Court of the United States, October Term, 1911.

THE PEOPLE OF THE STATE OF NEW YORK, Complainants,
against
STATE OF NEW JERSEY and PASSAIC VALLEY SEWERAGE COMMISSIONERS, Defendants.

CORPORATION COUNSEL'S OFFICE,
NEW YORK CITY, June 18th, 1912—10:30 a. m.

Present: James D. Maher, Esq., Commissioner.

Appearances:

Dr. William J. O'Sullivan, Special Counsel for the People of the State of New York, Complainants.

Adrian Riker, Esq., of Counsel for the Passaic Valley Sewerage Commissioners, Defendants.

Met pursuant to adjournment.

HARRISON P. EDDY a witness called on behalf of Complainants, recalled, for further examination, testified as follows:

Direct examination by Mr. O'Sullivan (resumed):

Q. Mr. Eddy, did you give any study to the determinations of dissolved oxygen made on November 13th, 1911?

A. I did.

Q. State what determinations were taken?

A. Determinations of dissolved oxygen, made on November 13, 1911, were as follows:

Mouth of Newtown Creek	3.41 c.c.	50%	saturation
Werner Ave. Bridge	0.84 c.c.	14.0%	saturation
Green Point Ave. Bridge	0.29 c.c.	5.0%	"
Meeker Ave. Bridge	0.0 c.c.	0.0%	"

2168 These determinations of dissolved oxygen appear to accurately indicate the conditions of this water as to the presence of large quantities of sewage contained in it, and the degree to which decomposition and purification extended. They also coincide with the observed facts, both as to general appearance of the water and the odor evolved from it.

The water at the mouth of Newtown Creek in October, appeared to contain about 50% of the saturation value of dissolved oxygen, and was polluted to such an extent that sewage odors coming from it could be detected. By observing the water from the stern of a tug there was no evidence that the surface water was much worse than that below the surface, as indicated by the stirring action of the propeller. This observation is borne out by the dissolved oxygen tests, which indicate the same degree of depletion of oxygen at the surface and at a depth of 20 feet more or less.

Judging from the observations as to the quality of the water and of the odors evolved from it, it appears that when there is sufficient sewage and when the decomposition has progressed sufficiently far to deplete the oxygen to 50% of the saturation value, the limit of pollution which can be safely permitted has been reached. It is true that water in certain places can receive a greater quantity of sewage with a given depletion of oxygen than water in other localities, depending upon the swiftness of the current, the amount of shipping, and disturbance of the water by propellers, the length of time that the water remains under the conditions being considered, temperatures, and the proportion of land and sea water. From the observations made, however, it does not appear to be safe, to allow the water in New York Harbor to be depleted of its oxygen to an extent exceeding 50% saturation value or 3 c. c. per litre.

2169 It should not be concluded that because the water in the mouth of Newtown Creek gives off offensive odors when containing 50% or less of dissolved oxygen, that the water of the East River, the Hudson River, or Upper Bay, will give off equally offensive odors when the dissolved oxygen is reduced to the same extent,—say 50%,—because these large bodies of water, which are free to move backward and forward, and which at each successive tide are replaced to some extent by fresh water from the Hudson River and from the sea, may not be in equally bad condition when the dissolved oxygen is reduced to 50 per cent of the saturation value. In fact the water, as a whole, in the Upper Bay, ought not to be permitted to become as badly polluted as the water at the mouth of Newtown Creek when it contained 3.41 c. c. of oxygen, equivalent to 50% saturation.

An examination of the Harlem river will be helpful in fixing the minimum quantity of oxygen below which the oxygen should not be depleted. On October 19, 1911, the water in the lower or East River water of the Harlem River was extremely foul. It was turbid because of the fresh sewage which it contained and there were large quantities of floating sewage matters to be seen almost constantly. Offensive sewer odors were given off from the water in this vicinity. In going up the river toward Hudson, there was a gradual though not rapid improvement in the quality of the water, and at the New York Central Railroad Bridge there were occassionally spots, or streaks of black water, indicating that there was mud on the bottom of the river, which was in the state of putrefaction. There was odor of putrefaction at this point. The dissolved oxygen in the water of the Harlem River was determined by the Metropolitan Sewerage Commission on July 10, 1911, a run being made between the East

2170 and Hudson Rivers. The results of these determinations are shown graphically upon Figure 5.

Q. Mr. Eddy, who made this graphic chart?

A. It was actually drawn by a draftsman under my immediate direction and I have checked it with the tables of dissolved oxygen furnished me by your office.

Mr. O'Sullivan: I offer that table designated as "Figure 5" being

the graphic chart described by this witness, prepared under his direction, I offer it in evidence and ask that it be marked Complainants' Exhibit No. 132.

Cross-examination by Mr. Riker:

Q. Where did you get the data on which this was prepared?
A. It was furnished by Dr. O'Sullivan.
Q. And how many observations is this based on?
A. I should think, judging from memory, about 30 or 40.
Q. And this represents in other form merely the figures that you were referred to by Dr. O'Sullivan?
A. Yes, sir.
Q. It does not contain any new matter?
A. No new matter except the figures were averaged by me. I ought to mention that.

Mr. Riker: The offer is objected to as being immaterial and irrelevant.

The Commissioner: Note the objection of Counsel for Defendants. Received and marked Complainants' Exhibit No. 132.

Marked Complainants' Exhibit No. 132.

Direct examination by Mr. O'Sullivan (resumed):

Q. Proceed, Mr. Eddy?
A. Near the East River, the dissolved oxygen was found to be only slightly above 20% saturation and the average of the analyses shows a gradual increase all the way to the Spuyten Duyvil
2171 Bridge. At the New York Central Railroad Bridge, the average saturation was slightly below 50 per cent. The quantity of oxygen present in the water, as determined on the flood current, was 3.11 c. c. and on the ebb 1.88 c. c. per litre. At this point the water was considerably better in appearance than it had been further down the river, and the odors, while distinct, were not nearly as strong and constant as at points further down. It was very evident that the oxygen in this water should not be depleted below 3 c. c. per litre.
Q. Now, Mr. Eddy, have you taken into consideration the relative quantities of dissolved oxygen at various points in the harbor in your study of this subject?
A. I have.
Q. With what results?
A. A comprehensive examination of the character of the water in the various arms of the Upper Bay, and in the Bay itself, was made by the Metropolitan Sewerage Commission in the months of September and October, 1911. The quantity of dissolved oxygen was determined in the water at several points across the Hudson and East River, the Kill van Kull, the Narrows, and in the Upper Bay, and seem to represent with accuracy the character of the water present in these different localities when the samples were taken.
The results of these determinations are as follows:

Cross-examination by Mr. Riker:

Q. It is not clear to my mind just what you did with the figures on the table that you are about to read?

A. It gives the maximum and minimum number of c. cs. of oxygen found in the waters specified in the table, and the average per cent. of saturation found on those days. The average I have prepared. The minimum and maximum figures are taken from the table and exhibits which Dr. O'Sullivan handed me.

Q. In getting your average, what did you take?

A. Merely the maximum and minimum?

A. Take all the averages.

2172 Q. Average of all samples?

A. The examinations, yes, sir.

Mr. Riker: The reading of the table into the record is objected to for the reason that it is founded upon figures that are not properly verified and an exhibit which is not properly in the cause.

The Commissioner: Note the objection of Counsel for Defendants.

Direct examination by Mr. O'Sullivan (resumed):

Q. Proceed, Mr. Eddy?

A. The results of these determinations are as follows:

	Date.	Range in oxygen c. c.		Average per saturation.
		Min.	*Max.*	
Hudson River at Mt. St. Vincent	Oct. 13	4.38	5.97	77.9
" " " Pier A	Sept. 28	2.73	3.62	55.0
East River at Pier 10, Brooklyn	" 29	2.73	3.36	54.0
Upper Bay	Oct. 16	3.96	4.68	72.0
Kill van Kull	" 4	4.10	4.78	75.0
Narrows	Sept. 26	3.69	5.04	78.0

It should be borne in mind that these determinations were made in the fall of the year when the temperatures of the air and of the water were slightly lower than would be the case during July and August, so that the results given are probably higher than would have been the case had the cross sections been made during the hot weather of the summer.

An examination of the temperature of the water near Robbins Reef, in 1911, shows a range from about 24° C. in the summer to 15° C. in late October, at this latter and lower temperature the water will dissolve 15% more oxygen than at the higher summer temperature. Furthermore, increased bacterial life in the hot

2173 weather causes a greater depletion of the oxygen in the summer than in the autumn.

It is important to note that at Mt. St. Vincent sufficient sewage had been diffused through the waters of the river to cause, directly

or indirectly, a reduction of the dissolved oxygen saturation value of 78% and that it had been reduced when the mouth of the river was reached, to 55% saturation.

Q. Did you prepare a figure to show these explanations?

A. That is shown on Figure 6. I might explain that the figures given on that chart or sketch map are the figures which have just been read into the testimony.

Q. Do they indicate the locations at which these percentage averages exist?

A. Yes, sir.

Cross-examination by Mr. Riker:

Q. This is an attempt to locate on a chart the positions of the averages of the samples which you have averaged in the table?

A. Yes, sir, simply in a general way, to show their relative locations.

Mr. O'Sullivan: I offer this chart in evidence, and ask that it be marked Complainants' Exhibit, No. 133.

Mr. Riker: The offer is objected to for the same reasons that the table was objected to.

The Commissioner: Note the objection of Counsel for Defendants. Received and marked Complainants' Exhibit No. 133.

Marked Complainants' Exhibit No. 133.

Direct examination by Mr. O'Sullivan (resumed):

Q. Proceed, Mr. Eddy?

A. It is important also to note that the character of the water in East River near its mouth was substantially the same as that of the Hudson River at is mouth. From the Battery there appears to be a gradual increase in the quantity of dissolved oxygen as the Narrows are approached, at which point the average saturation was found to be 78.6%. The character of the water at or near
2174 Robbins Reef was distinctly inferior to that at the Narrows, but it was somewaht better than that at the Battery, showing the effect of the dilution with fresh sea water coming in through the Narrows at times of flood tide. The dissolved oxygen tests made on July 12, 13, Figure 7, when a course was run from Yonkers to the open sea at Buoy 6 in Ambrose Channel.

Q. One moment. Did you prepare a figure known as Figure 7 to show that?

A. I have, yes, sir.

Q. Under whose direction was Figure 7 prepared?

A. Under my direction.

Q. What is it?

A. It is a graphic illustration of the determinations of dissolved oxygen as made on July 12 and 13, 1911 by the Metropolitan Sewerage Commission of New York. It is based on figures furnished me by your office and includes averages which I have myself computed.

Q. From these exhibits that are in evidence?

A. From these exhibits that are in evidence, yes, sir.

Mr. O'Sullivan: I offer this chart described by this witness in evidence and ask that it be marked Complainants' Exhibit No. 134 in evidence.

Cross-examination by Mr. Riker:

Q. This is merely a draftsman's representation of figures furnished you, which you have no knowledge of other than they were furnished to you?

A. Yes, sir.

Mr. Riker: The offer is objected to on the ground that it is based upon figures which the witness has no knowledge of, other than that they were furnished him by Counsel for Complainants and on the ground that these figures are not properly in evidence in this case and are not evidential of any matter in controversy in this case.

The Commissioner: Note the objection of Counsel for De-
2175 fendants.

Received and marked Complainants' Exhibit No. 134.

Marked Complainants' Exhibit No. 134.

Mr. O'Sullivan: Counsel for Complainants desires to state that the figures alluded to are contained in Complainants' Exhibit No. 31 and Complainants' Exhibit No. 94, that are here now, and are offered to Counsel for Defendants for comparison.

Mr. Riker: Counsel for Defendants is aware of what they are based upon, but draws attention to the fact that the exhibits named are marked subject to objection on the part of Defendants' Counsel, and are not admitted to be proper exhibits in this case.

The Commissioner: Note the objection of Counsel for Defendants.

Direct examination by Mr. O'Sullivan (resumed):

Q. Mr. Eddy, you were discussing the dissolved oxygen tests which you prepared in this graphic form as shown in figure 7. Will you proceed?

A. These analyses show relatively little difference between the character of water at Robbins Reef and that at the Battery, and indicate that the water at Robbins Reef has only slightly more capacity for receiving and assimilating sewage than that at the Battery. It is, therefore, proposed to discharge the sewage from 1,649,000 persons at a point in New York Harbor where the dissolved oxygen in the water is nearly as low as at any point in the main arteries.

Q. Now, Mr. Eddy, assume that the facts and data have been proven as set forth in Complainants' Exhibits from Numbers 1 to 126 inclusive; assume that these exhibits from Numbers 1 to 126, inclusive, set forth correctly the observations, statistics, chemical analyses, bacterial determinations, photographic reproductions of places and things observed; charts and maps of contours of surface and sub-surface localities, apparatus employed, together with
2176 the reports made thereon by the observers, and now in evidence in this case, have been proven. Assume, also, that the

tabulations of oxygen determinations, the tabulations of bacterial count; the tables of averages for oxygen determinations, bacterial count and harbor deposits; the charts plotting float observations, oxygen percentages, bacterial count, and mud examinations, the current observations, report of tidal actions, and graphic charts thereof; current velocities, indices of sample stations and plottings thereof, microscopic examinations of harbor deposits, photographs and charts of sewage fields, dispersion areas, and sleek fields; all as set forth in Complainants' Exhibits from Numbers 1 to 126, inclusive, and such other scientific data as are included in these exhibits, are proven.

Assume, also, that the testimony which you have reviewed and which has been given by witnesses preceding you in the hearings in the present suit between the State of New York and the State of New Jersey, on all these enumerated matters, and also on the precipitation; run-off; present and prospective populations of the drainage areas, and such other scientific data as has been included in the testimony given thereon, have proven the matters therein testified to—

Taking all these facts and circumstances of record in this case, and facts observed by you, into your full consideration, what, in your opinion, will be the results of the contemplated discharge from the Passaic Valley Trunk Sewer outlet into New York Upper Bay, in the vicinity of Robbins Reef, on the Harbor Waters and tidal waters of New York Harbor, under present existing conditions and under prospective conditions, on or about the year 1940, and during the intervening period between the present year 1912, and the year 1940? In your answer, I desire you to discuss the matter as to its local and general effect.

Mr. Riker: The question is objected to on the ground that it does not state the evidence which has been produced in this cause,
2177 and is not a basis for opinion evidence, in the form in which it is propounded to this witness, and on the further ground that it calls for several answers in one reply.

The Commissioner: Note the objection of Counsel for Defendants.

Mr. O'Sullivan: I reply to the objections of Defendants' Counsel, Counsel for Complainants desires to point out, that to have a comprehensive hypothetical question would embrace the entire subject matter and would be merely a *reputation* of the entire case, so far as contained in several volumes of typewritten testimony. Counsel for Complainants also desires to direct the attention of Counsel for Defendants to the case of Transportation Line vs. Hope, Reported in 95 U. S. at page 297, quoting from page 298, where it is indicated to be the rule of the court that it is not necessary to assumae a state of facts in those cases in which the expert is personally acquainted with the material facts in the case.

Mr. Riker: Further objection is made to the question on the ground that it does not state the matters of fact that are assumed

to have been proved in the case, and brought to the attention of the witness, and upon which the witness' opinion is sought.

The Commissioner: Note the objection of Counsel for Defendants.

Q. Before you answer my question, Mr. Eddy, I would like to ask if you have examined the exhibits included in the question?

A. I have, yes, sir.

Q. You may proceed.

A. The sewage which it is proposed to discharge at Robbins Reef, will be devoid of oxygen and putrefaction will have set in especially during that portion of the year when the temperature of the sewage is relatively high. In this condition the oxygen in the harbor water will be quickly depleted and an immediate reduction of the supply will be noticeable in the vicinity of the outlet. At times of slack water the proportion of sewage contained in the water within
2178 the dispersion area will be relatively high, and so high that the quantity of dissolved oxygen will be reduced below 50% saturation. As the tide comes in after slack low water, the admixture of sewage and harbor water, which has formed during the period when the currents were slight or practically nil, will be gradually and slowly pushed in a northerly direction, and in time and after having been driven a considerable distance, will become more or less completely diffused with the surrounding waters of the Bay. A similar condition will obtain when the tide turns to go out. The sewage discharged during slack high water will be sufficient to materially reduce the oxygen in the water over and immediately around the dispersion area, and this volume of water will be slowly and gradually pushed towards the Narrows and will be gradually diffused in the surrounding waters, so that it may ultimately lose its identity.

The general effect of the discharge of sewage at Robbins Reef will be to cause a large increase in the quantity of dissolved putrescible matter in the waters of the harbor and a reduction in the quantity of oxygen dissolved in these waters. If the quantity of dissolved oxygen in the waters of the Upper Bay is reduced, it follows that the water entering the Hudson and East Rivers, the slips, bays, creeks, and other arms of the Bay, will have less capacity than at present for assimilating the impurities which are discharged into them Where conditions at the present time are satisfactory because the quantity of oxygen in the water is sufficient to provide for the assimilation of the sewage, the conditions may be very different if the water entering these arms of the Bay is depleted to a greater extent of its supply of dissolved oxygen, as will be the case if the Passaic Valley project is carried to completion.

Cross sectional studies were made to determine the quantity of oxygen dissolved in the water at various points, and the averages of these determinations are shown upon Figure 6, p. 60.
2179 The result of these studies indicate clearly that the water in the vicinity of the Battery is now approaching, if it has not already reached, the limit of safe reduction of dissolved oxygen—the average per cent. saturation found at the time these tests were

made being 55% at the mouth of the Hudson and 54% saturation in East River at the Battery.

No cross section of the Upper Bay was made in the vicinity of Robbins Reef. Numerous tests, however, were made on October 16, 23, and November 4, 1911. These tests indicate that the dissolved oxygen is approaching the safe limit of depletion, the minimum quantity found on any of these tests being 3.96 c. c. per litre, equivalent to 65% saturation. These results were obtained on October 16, 1911, and apply both to surface and deep samples. The temperature of the water at this time was about 61° Fahr. and about 30% of the water was land water.

The dissolved oxygen tests show very clearly that the waters of the harbor at all points covered by the tests now receive sufficient sewage to cause a material reduction from the saturation value of the dissolved oxygen, and at several points—as the mouth of the Hudson, the East River at the Battery and Upper Bay at Robbins Reef—the oxygen is reduced to a point approaching the permissible limit. A further increase in the quantity of sewage discharged into these waters will cause a further decrease in the amount of dissolved oxygen, and it follows that the discharge of a large quantity of sewage at the Robbins Reef Light will cause a material decrease in the dissolved oxygen in the waters of the Upper Bay.

Q. Mr. Eddy, have you taken into consideration the provisions as set forth in the specifications of the results in the stipulation or contract entered into between the State of New Jersey and the Federal Government?

A. I have. Under the second part of the agreement between the United States Government and the State of New Jersey and
2180 the Passaic Valley Sewerage Commission, are found certain specifications of results which the Passaic Valley Sewerage Commissioners have agreed to produce. These may be considered briefly as follows:

1. There will be absence in the New York Bay of visible suspended particles coming from the Passaic Valley sewage.

The work proposed consisting of coarse and medium coarse screens and sedimentation tanks of specified dimensions, will not produce an effluent free from visible suspended particles.

Mr. Riker: I object to that and move that it be stricken out in so far as the stipulation is not correctly stated in the answer.

The Commissioner: Note the motion and objection of Counsel for Defendants.

Q. Proceed, Mr. Eddy?

A. —And the methods of discharge into the harbor will not be ample for the dissipation of the sewage in the harbor water to such an extent as to insure the absence of visible suspended particles.

Mr. Riker: This part of the testimony I will move to be stricken out as it is based on a misstatement of the stipulation.

The Commissioner: Note the motion of Counsel for Defendants.

Q. Proceed, Mr. Eddy?

A. There will be absence of deposits objectionable to the Secretary of War of the United States in New York Bay coming from the Passaic Valley Sewage.

Mr. Riker: I will read the stipulation to him, page 3, "The State of New Jersey and the Passaic Valley Sewerage Commissioners further agree with the United States that in the operation of said sewer system, provided the permit for its construction referred to in Article V of this instrument has been granted, at all times the following results shall be secured, either through compliance with the requirements of the immediately preceding paragraphs, or through requisite lawful additional arrangement." His attention is drawn to
2181 the fact that it is a misstatement of the stipulation to refer only to one of the provisions.

Q. Mr. Eddy, I hand you a certified copy of the stipulation entered into between the United States Government and the State of New Jersey and ask if that is the stipulation that you took under consideration during your discussion of the terms of the stipulation entered into?

A. I think it is.

Mr. O'Sullivan: I offer that certified copy of the stipulation in evidence and ask that it be marked Complainants' Exhibit No. 135.

Mr. Riker: He testified that with the means specified in the stipulation, these results could not be obtained, and I am drawing his attention to the material part of this stipulation which he has neglected apparently.

The Commissioner: Received and marked Complainants' Exhibit No. 135.

Marked Complainants' Exhibit No. 135.

Q. Mr. Eddy, I direct your attention to Complainants' Exhibit No. 135 and ask you to find in that stipulation the language that you have employed here in your testimony relative to the suspended particles. On what page of that Exhibit?

A. It is on page 4.

Q. Read the part from that?

A. "There will be absence in the New York Bay of visible suspended particles coming from the Passaic Valley Sewage."

Q. Have you now read from the exhibit?

A. I have.

Mr. Riker: The objection is made that the witness has attempted to justify his testimony by taking out a clause from a sentence and disevering it from its proper connection.

The Commissioner: Note the objection of Counsel for Defendants.

Q. After reading that stipulation from the exhibit, state what your views are upon it and the methods provided for its accomplishment?

Mr. Riker: The question is objected to in that it being
2182 a witness' opinion upon a stipulation, involves questions of law in the first place, and in the second place that the clause

in question, dissevered from its proper connection, is not a fair basis for opinion evidence.

The Commissioner: Note the objection of Counsel for Defendants.

Q. Mr. Eddy, have you considered the stipulations as a whole?

A. I think I have.

Q. And have you considered the methods described for securing the results embodied in the stipulation?

A. I have.

Q. Take that first stipulation that you have just read.

Mr. Riker: I would like to ask the witness a question at this stage.

Cross-examination by Mr. Riker:

Q. What part of the stipulation have you considered?

A. The whole of it, I think.

Q. And you say that you have considered the means that are specified in the stipulation?

A. Yes, sir.

Q. Have you considered that the stipulation as to results is based in the disjunctive, either through compliance with the requirements of the immediately preceding paragraphs, or through requisite lawful additional arrangements?

A. I have taken that into consideration, yes, sir.

Q. And you say that you are going to testify now as to what can and can not be accomplished under this stipulation.

A. By the work specified.

Q. What works did you take into consideration as part of the work assumed through requisite lawful additional arrangements?

A. There is no specification as to what they may be.

Q. Then you are only going to take one part of the disjunctive.

A. So far as the works are specified.

Direct examination by Mr. O'Sullivan (resumed):

Q. You may proceed?

2183 A. The works proposed consisting of coarse and medium coarse screens and sedimentation tanks of specified dimensions, will not produce an effluent free from visible suspended particles, and the method of discharge into the harbor will not be ample for the dissipation of the sewage in the harbor water to such an extent as to insure the absence of visible suspended particles.

Q. Now, take the second stipulation in Complainants' Exhibit No. 135?

A. There will be absence of deposits objectionable to the Secretary of War of the United States in New York Bay coming from the Passaic Valley Sewage.

Q. What is your opinion relative to the means prescribed for the accomplishment of that result?

A. It is clear that much of the suspended matter discharged into the harbor from the Passaic Valley sewerage works will settle and

form deposits. Whether or not these deposits will be objectionable to the Secretary of War of the United States cannot be stated.

Q. You cannot tell whether or not this would be objectionable to the Secretary of War, can you?

A. I cannot.

Q. Take the third stipulation?

A. There will be absence in the New York Bay and its vicinity of odors due to the putrefaction of organic matters contained in the Passaic Valley sewage thus discharged.

In the foregoing discussion it has been pointed out that the sewage will at times be putrid and will give off very offensive odors. The provision for diffusion of the vast amount of sewage does not appear to be ample to prevent these odors from being given off by the waters of the harbor in the vicinity of outlets and they may at times be given off at distances quite remote from said outlets.

Q. Take the fourth stipulation in Complainants' Exhibit No. 135, read from the exhibit?

A. There will be a practical absence on the surface of New York Bay of any grease or color due to the discharge of the Passaic
2184 Valley Sewage at the dispersion area or elsewhere.

There will be grease in considerable quantities in the vicinity of the outlets and that at times there will be a decided discoloration of the harbor waters caused by the coloring matters originating in the industrial wastes discharged into the Passaic Valley Sewer. Furthermore, at time of great putrefaction in the sewage it is probable that there will be a darkness of the waters in the vicinity of the outlets, due to the black sewage effluent discharged into them.

Q. Now, Mr. Eddy, can you summarize the results which in your opinion will follow from the discharge of the sewage from the Passaic Valley trunk sewer at Robbins Reef?

Mr. Riker: The question is objected to on the ground that it does not appear in the evidence in what condition the sewage is to be discharged under the project at Robbins Reef, and that an opinion upon matters which are not evidential is of no value and not admissible in this cause.

The Commissioner: Note the objection of Counsel for Defendants.

A. Taking into consideration the quantity and character of the sewage which will be discharged at Robbins Reef, if the Passaic project is carried on to completion, and taking into consideration also the method of dispersion proposed it is reasonable to expect the following results:—

The water in the immediate vicinity of the outlets will at times contain floating sewage matters which can be readily recognized as such.

Small particles of grease will be seen floating or suspended upon or in the water.

There will be oily sleek upon the surface of the water, which will cover large acres and will be traceable for long distances from the

outlets. At times coloring matters, originating in industrial
2185 wastes, will cause a discoloration of the waters in the neighborhood of the outlets, and this discoloration will cover large areas and be traceable for long distances.

If by any chance, the sewage is discharged in a relatively fresh condition, it will cause an increase in turbidity and give to the water a milky and dirty appearance.

During the warmer weather the sewage will have undergone decompos-tion to such an extent that it will be dark colored and give to the water a dark appearance.

At practically all times the sewage will add materially to the quantity of finely divided suspended matter and increase the turbidity.

The sewage will at times, especially in hot weather, contain large quantities of suspended matter some of which will be re*al*tively coarse and will be recognizable as of sewage origin. This suspended matter will be deposited at various points in the harbor where the velocity is relatively low and will consume oxygen from the overlying water.

The quantity of organic matter in the sewage discharged from these outlets, will be very great and will cause a rapid diminution in the supply of dissolved oxygen in the waters of the harbor.

At times of storm the sewage will contain large quantities of detritus from the streets. This matter will be carried through the sedimentation basins and will be discharged with the effluent in quantities up to the capacity of the intercepting sewer, which will be 18 million gallons per hour. This immense quantity of sewage will find its way to the surface of the harbor water, and will cause the discoloration of large areas of the harbor, giving to the water a d*i*try muddy appearance. This condition will result after summer showers when the water may be used for pleasure purposes, and will constitute a condition which will be highly objectionable to persons using the
harbor for recreation purposes. The muddy water thus dis-
2186 charged will undoubtedly find its way long distances from the outlets, so that its effect will not be wholly local.

Th sewage, especially during the warm season of the year will have undergone decomposition to such an extent that it will have become putrid and will give rise to highly offensive odors.

This sewage will rise to the surface of the harbor water and at times will give off into the overlying atmosphere a portion of the odors which it contains. It may therefore be confidently expected that offensive odors will be noticed in the vicinity of the outlets, and, under conditions which cause the sewage to stream toward Staten Island and toward Manhattan, odors may at times be observed which can be attributed to this sewage.

Mr. O'Sullivan: Your witness, Mr. Riker.

Cross-examination by Mr. Riker:

Q. Where were you educated, Mr. Eddy?
A. Worcester Polytechnic Institute, Worcester, Massachusetts.
Q. And when was that?

A. I graduated in 1891.

Q. And from there where did you go?

A. I still resided in Worcester and I entered the employ of the City of Worcester, almost immediately after graduation.

Q. Did you conduct further study after your graduation in the Worcester Institution?

A. Not in an educational institution. I have conducted continuous experiments and studies of sewage purification problems from that day to this.

Q. How old were you when you graduated?

A. When I graduated I was 21.

Q. Your first employment was what?

A. My first employment was as member of the Grade Party of the City of Worcester. That was prior to my graduation.

Q. Did it have anything to do with sewerage or sewage disposal?

A. That did not, no, sir.

Q. What was your first employment in connection with sewerage work?

A. During my course at the Institute I was employed to
2187 equip the laboratory and do some chemical and experimental work in connection with the purification of sewage at Worcester.

Q. That was laboratory work?

A. That was, yes, sir.

Q. And what was your first connection with any actual sewer project?

A. In August I think, of the year 1891; the year after graduation. I took charge of the purification works at Worcester as Superintendent.

Q. What were those works when you took charge of them?

A. The works for the chemical precipitation of sewage.

Q. By what process?

A. By chemical precipitation.

Q. Is there any special name to it?

A. No special name. You might define it perhaps by saying the process consists of the addition of lime to the sewage, which, by chemical combination with the iron in the sewage caused a precipitation and a clarification of the sewage.

Q. And producing what kind of an effluent?

A. Clear colorless effluent, generally, practically free from suspended matter, usually not over 5 per cent of the suspended matter remaining in the sewage.

Q. Where was that effluent discharged, where did you connect it with the Worcester system?

A. The Blackstone River.

Q. Does that river run through Worcester?

A. Yes, sir.

Q. And at what point with reference to the City was the effluent discharged?

A. About 3 miles below the center of the City.

Q. Does that river flow through a populated district after it leaves Worcester?
A. Yes, sir.
Q. Through other towns and villages?
A. Yes, sir.
Q. Now, what was your next work in Worcester?
A. During my first year in Worcester, we began the enlargement of the purification works, to take a larger quantity of sewage and I did considerable to assist the head of the department in the building of those works. I was not in official charge of the construction
2188 which was done during that first year; the following year, in November, that would be 1892, I was elected the head of the department and had entire charge of constructing the plant which was then being enlarged.
Q. And the enlarged plant, did that use the same methods of purification?
A. Yes, sir.
Q. And discharged the effluent to the same point?
A. Yes, sir.
Q. And in the same condition?
A. Substantially, as near as I could say.
Q. Well, in that effluent, was there absence of visable suspended particles?
A. No, sir.
Q. There was not?
A. No, sir.
Q. Still you discharged it into the fresh water stream?
A. Yes, sir.
Q. Flowing through populated communities?
A. Yes, sir.
Q. How do you distinguish between a clear effluent and an effluent containing suspended particles?
A. An effluent that is absolutely clear does not contain visable suspended particles.
Q. Did you not say that the effluent from these works was clear?
A. Speaking in a general way, a common way, I did. Strictly speaking, it is not scientifically clear.
Q. You are not speaking scientifically then?
A. Not with scientific accuracy on that point.
Q. When the effluent was discharged into the waters of the river that you have referred to, were there visable suspended particles coming from the effluent?
A. I think there were; yes, sir.
Q. Do you know?
A. I feel sure there were.
Q. Did you ever observe?
A. I did.
Q. And you saw them?
A. Yes, sir.
Q. And nevertheless, as an engineer, you continued to discharge

that sort of an effluent into the waters of the Blackstone
2189 River?

A. That water was discharged; yes, sir.

Q. Under your charge as superintendent?

A. I had charge of that work.

Q. You were the expert in charge of it?

A. I was in charge of it.

Q. In that effluent, were there produced in the bed of the Blackstone River deposits of solid matter?

A. Undoubtedly the suspended matter from the effluent found its way to the bed of the stream and added to the deposits caused in other ways from other sources.

Q. So that as a matter of fact, this purification so-called, was no purification at all?

A. I should not say so; no, sir.

Q. You should not?

A. I should not say that.

Q. What would you say with reference to the purification?

A. It is a purification. The purification effected was commonly spoken of—was commonly measured by giving the percentage of removal of various substances, the amount removed, varying from 50 to 55 or 60 per cent.

Q. Were there odors connected with this effluent?

A. There was always a distinct odor, yes, sir.

Q. And that produced a marked odor in the river into which it was discharged?

A. I think it did produce some odors at times.

Q. How much sewage was there treated at the maximum while you were in charge of these works?

A. Why, I should say at times the quantity ran up to 20 or possibly 23 or 24 million gallons per day.

Q. What was the population of the district served by the sewers at the time that you were in charge?

A. I think under 100,000 at the time I have testified about in 1892.

Q. And was the system, the sewerage system a combined or
2190 dual system, or was it a separate system?

A. In 1892 it was a combined system, with the exception of a very few separate sewers.

Q. Is Worcester a manufacturing City?

A. Yes, sir.

Q. Was trade wastes present in this sewage?

A. Yes, sir.

Q. Do you know whether that system is still in operation in Worcester?

A. I do.

Q. Is it?

A. It is.

Q. Discharging its effluent into this fresh water river?

A. Yes, sir.

Q. Was there any grease or odor or color due to the discharge of the effluent into the waters of the Blackstone River?
A. I think at times there was; yes, sir.
Q. Do you remember observing it?
A. I have.
Q. Do you know what the population of Worcester is now?
A. Approximately 145,000.
Q. That is the district served by these sewers which discharged their effluent into this river?
A. It is.
Q. How long did you continue in charge of the sewerage system of Worcester?
A. Until the last of April 1907.
Q. And at that date can you state how much of the daily discharge of the sewage was through the effluent?
A. The average quantity I should say was approximately 14 million gallons per day.
Q. And is that the time that you have said that you observed there had been no change made in the process or methods in the treatment at Worcester?
A. I did not say that.
Q. Was that the time; do you know anything about it since that date?
A. I do.
Q. And how late have you knowledge?
A. Up to within the last year.
Q. Is the same process being used?
A. The same process is being used.
2191 Q. Now, while you were in charge of the Worcester system, did you do any other work in the sewage line?
A. You mean outside of the City of Worcester?
Q. Yes.
A. Outside of the City work you mean?
Q. Yes.
A. I did.
Q. Where?
A. I did work for the City of Boston; for the City of Pittsfield, for the City of Westboro; for the City of Pittsburgh, for the City of Louisville, Kentucky; for the City of Gloversville, New York.
Q. Now, let us take the Westboro enterprise; what was that?
A. That was a case in court where the Complainant alleged that his farm land had been depreciated in value, or his crops had been injured by the discharge of the effluent from the sewage purification works.
Q. This had nothing to do with the construction of the works?
A. It did not.
Q. You simply testified as an expert in the suit?
A. I testified in the suit.
Q. Not as an expert?
A. I presume I was so classed.
Q. And for which side in the suit did you testify?

A. For the City.

Q. Defending the City against the charge of injuring the lands of the plaintiff?

A. Yes, sir.

Q. What was the character of the effluent in that case?

A. The effluent was a fairly well oxidized sewage as I remember it.

Q. Produced under what system, do you mean?

A. Intermittent filtration through sand filters.

Q. When was that suit and when did you testify?

A. About the year 1902.

Q. And what was the amount of the discharge of the
2192 effluent per diem?

A. I should say from one to two hundred thousand gallons per day, probably.

Q. Did you examine that effluent?

A. I did.

Q. Did it contain visible suspended particles?

A. I think not, as a rule. It may have occasionally.

Q. Did it cause deposits of sewage matter in the stream in which it was discharged?

A. Undoubtedly the suspended matter was deposited, if it was there.

Q. I did not ask you that. I asked you whether it did, if you know; if you do not know, say so?

A. I do not know.

Q. Were there odors produced in the waters of the stream into which the effluent was discharged, so far as you know?

A. I do not think there were.

Q. Was there grease or color produced in the waters of the stream into which the effluent was discharged, due to the discharge of that effluent?

A. I do not think there was grease; there undoubtedly at time was color.

Q. Did you ever see any?

A. I did see white, whitish turbidity at times.

Q. What was the stream into which this effluent was discharged?

A. The Assabet River.

Q. A fresh water stream?

A. Yes, sir.

Q. Flowing through a populated community below the point of the effluent's discharge?

A. Very sparely populated.

Q. Now, take Pittsfield, what did you do there?

A. I advised the City with reference to litigation brought by a farmer owning adjoining land, land adjoining the purification works?

Q. You advised the City; did you testify?

A. I did not. The case did not come to trial, I think.

Q. You had nothing to do with the construction of that system?

A. I did not.

Q. You examined it, I presume?

A. I did.

Q. What kind of a purification plant was that?

2193 A. That was an intermittent sand filtration plant.

Q. And discharging its effluent where?

A. Into a very small brook. I do not know the name of it.

Q. And do you know where the waters of the brook discharged themselves?

A. I do not remember.

Q. Do you not know through what communities the effluent passed after it left the sewer?

A. I could not say, no, sir.

Q. You did not follow it?

A. No, sir, I did not follow it at all.

Q. Did you examine the effluent?

A. I cannot say certainly; I think I did.

Q. When did you make your visit to Pittsfield for this purpose?

A. I should think about 1902.

Q. And can you recall whether or not you observed visible suspended particles in the brook into which this effluent was discharged, due to the discharge of the effluent?

A. I do not remember.

Q. Nor whether there were deposits made in the bed of the brook?

A. I do not remember that.

Q. Or whether there will be any odors in the brook due to the discharge of the effluent?

A. I do not remember that.

Q. Nor whether there was any grease or color visible in the waters?

A. I do not remember. I did not examine the brook particularly.

Q. Well, now, take Louisville, Kentucky, what did you do there?

A. Designed a system of sewers.

Q. How long ago?

A. That was in 1906.

Q. For what part of the City of Louisville did you design it?

A. Covering portions of the entire city, all parts of the City.

Q. And how many miles of sewers?

A. I think the original plan included about 50 miles.

2194 Q. Did you construct them all?

A. They have been very largely constructed; no, I think not, every section.

Q. How large a population do they serve?

A. About 250,000—no, I think about 240,000.

Q. Are the sewers a combined system or a separate system?

A. Both systems have been built there and are now in existence.

Q. Under your plans?

A. Yes, sir.

Q. That is to say both sewers, taking the combined storm water and house sewage, and separate systems?

A. Yes, sir.

Q. Do you know the proportions?

A. The proportion of the city served by the separate system is rel-

atively small. I should say not more than 10 per cent. of the area of the City.

Q. Now, what treatment, if any, is given to the sewage at Louisville, under this system that you have designed?

A. No treatment.

Q. It is discharged where?

A. Into the Ohio River.

Q. Without purification?

A. Without purification.

Q. Is there any other system that you have designed where a purification works was part of the system?

A. Not where I have designed the system of sewers as a whole. The City of Fitchburg, Massachusetts, there I have designed some of the sewers.

Q. And you also designed a purification plant?

A. Yes, sir.

Q. When was that?

A. That is current now? The designs are not completed.

Q. And the purification plant is not even in partial operation?

A. No, sir, the sewage is not collected by the intercepter which I have designed for the part constructed.

Q. What is the system you are installing there?

2195 A. The purification system you mean?

Q. Yes.

A. The first part of the process is a grit chamber with coarse screens. The second step will be sedimentation in Imhoff or Emscher tanks. The third step will probably be mechanical filtration of the effluent. That is not finally decided upon. It may be a fine screening of the effluent. The fourth step will be the construction of percolating or trickling filters. The fifth step will be sedimentation of the effluent from these filters, and possibly a sixth step will be the collection of the effluent from the secondary sedimentation tanks by intermittent sand filters, one of which at least will be constructed for the filtration of a part of the effluent. There will also be a number of intermittent sand filters for the filtration of another part of the sewage which does no go through the trickling filters.

Q. And where is the effluent to be discharged?

A. That will discharge into the north branch of the Nashua River.

Q. And that branch unites into the Nashua River?

A. Then the south branch comes at Lancaster.

Q. And flows through well populated communities?

A. Yes, sir. In general, a great deal of farming country. Goes near communities, towns.

Q. That system not *have* been put in operation, you cannot now say what, of course, the character of the effluent actually is?

A. I cannot.

Q. It is, however, designed to accomplish certain results?

A. Yes, sir.

Q. And with reference to vis*able* suspended particles, it is designed to remove them?

A. Absolutely.

Q. Is there no method that you know of that will r-move visible suspended particles?

A. I do not think I have ever seen a purification plant which can be said at all times to absolutely remove all of the suspended matter.

2196 Q. Well, in your opinion, will or will not this effluent which will be produced from the work that you have described if discharged into New York Bay be free—show an absence of visible suspended matters in the water of New York Bay?

A. I think there would at times be suspended matter discharged into New York Bay.

Q. Visible?

A. Visible suspended matter, yes, sir.

Q. Will, in your opinion, the effluent from the works that you have described cause deposits in the bed of the north branch of the Nashua River of sewage matter?

A. I think that is quite probable.

Q. And will there be odors due to the putrefaction of organic matters in the waters of the Nashua River due to the discharge of this effluent?

A. I do not expect odors.

Q. And do you anticipate, as an expert, from the discharge of this effluent into the branch of the Nashua River which you have named, grease or color, due to the discharge of the effluent?

A. While the sewage is in its present condition, I should say there would not be color, unless it would be whitish or turbid appearance. It is possible that some particles of grease will pass through the percolating filters and the secondary sedimentation tanks and find their way into the river.

Q. Now, the Gloversville system that you testified in regard to; did you design that?

A. I did.

Q. What kind of a system is that?

A. That system consists of screens followed by sedimentation in vertical tanks, the effluent from which will flow direct through percolating or trickling filters, the effluent from which will pass through secondary sedimentation tanks, and from there will go to sand filters operated as intermittent filters.

Q. Is that system now in operation?

A. It is not.

Q. That is not the same type of purification works that
2197 you have described with reference to the last place?

A. Fitchburg?

Q. Fitchburg?

A. There are some modifications. It is very similar to that.

Q. Do you or do you not expect the same general character of effluent from these works as from the Fitchburg works?

A. I should expect that the effluent from the Gloversville works would be inferior to that at Fitchburg, because of the difference in the character of the sewage.

Q. Where is the effluent from that system to be discharged.

A. Into a small creek which flows into the Mohawk River. I think it is Cayadutta Creek, or another creek there.

Q. Where does the creek in question go with reference to the cities or towns?

A. It passes through Johnstown and Fonda, and enters the Mohawk River near Fonda.

Q. You have testified as to some plant in project for East Orange, Montclair, Glen Ridge and Bloomfield. Did you design a plant for them?

A. I did, in a most general way. It did not include drawings. Simply an outline suggestion as to a plant.

Q. And where did you design discharging the effluent from the plant?

A. I think into the Hackensack River.

Q. Then you designed to convey it across the Passaic River?

A. Yes, sir.

Q. You do not have any knowledge of the plan which they have now under consideration?

A. I do not know what they have now under consideration.

Q. You do not know that they propose to discharge it into the second river?

A. I do not.

Q. You have spoken of the Imhoff system, Mr. Eddy. What connection have you with that system?

2198 A. I do not know that I have any.

Q. No business arrangement; is it a patent system?

A. Yes, sir.

Q. You have no business connections with the owners of the patents?

A. I never have had any.

Q. Have you any now?

A. No, sir.

Q. Have you any in prospect?

A. No, except such as may result from having to deal with them in securing the privilege of using their patents in the City of Fitchburg.

Q. Do you know Mr. Hazen?

A. I do, yes, sir.

Q. Is he an engineer of standing?

A. He is.

Q. Do you know Mr. Edlow Harrison?

A. I have met him.

Q. Is he an engineer of standing?

A. I think so.

Q. Do you know Mr. Rudolph Hering?

A. I do.

Q. Is he an engineer of standing?

A. He is.

Q. They are all in the sewage line, are they not?

A. Yes, sir.

Q. In your opinion as to the results of the operation of the pro-

posed sewer discharging at Robbins Reef, you are aware that you differ from these gentlemen, are you not?

A. I am not? I do not know what their views are.

Q. You never have seen a statement by them that was authentic?

A. Unless there is something in the Passaic Valley Sewerage Commissioners' Report for 1908, which Mr. Hering wrote, which deals with that, and I do not remember in detail what that was.

Q. What familiarity have you with the conditions that exist in New York Harbor from personal observation?

A. I have made several trips around the harbor. I made three, I think, last year, and observed the water from the Battery several times and across the Hudson in ferries. I have been around down through the Upper Bay in boats,—I think the last time that
2199 I came across from the other side we anchored in the Upper Bay for a short time, an hour or two.

Q. Have you made any direct personal study of the sewage systems of the greater City of New York?

A. I have not.

Q. Do you know what population they serve?

A. Except that I know somewhere near the population of the City of New York; not from actual study of the population served by the individual sewers.

Q. And do you know the character of the discharge with reference to purification of the sewage of the Greater City of New York?

A. I think I do.

Q. What is that?

A. It is not purified to any great intent. I think there are a few small purification plants. As a rule it is discharged directly into the tidal waters.

Q. Do you know whether the sewers are combined sewers or separate?

A. So far as I know they are combined. I know that many of them are combined.

Q. And with reference to the mean level of the waters in the Bay, do you know at what point the discharge is?

A. As I have observed them, largely at or near the surface.

Q. What population do you understand is served by these sewers?

A. The population of New York which I believe is about 5 million people.

Q. And have you observed the outlets of the sewers with reference to the pierhead lines and the bulkhead line or shore lines of the City?

A. I have.

Q. Where are they located as a general thing?

A. I have seen them both ways. I should say more generally at the bulkhead lines than at the pierhead lines.

Q. Discharging into the slips?

A. Very largely; yes, sir.

Q. How long have you been familiar with these conditions in New York City.

A. I should say ten or fifteen years.

Q. And there has been no change in your observation during that period, except the addition of sewers?

A. No, sir.

2200 Q. Located in about the same way?

A. Yes.

Q. Now, have you made any study of the effect of the discharge of the crude sewage of New York City into the waters of the harbor under the conditions which you say you have observed with reference to the point of discharge, and the height, with reference to the level of the water?

A. I have.

Q. And what is the result, in your judgment, as based upon your personal observation of this discharge upon the character of the water of New York Harbor?

A. It reduced the normal quantity of oxygen dissolved in the water. It adds to the color, the turbidity, the suspended matter, and it causes the deposit in the slips and elsewhere of banks of sewage mud resulting in decomposition and ebullition of gas, which is seen bubbling up through the water. In some places it produces more or less odor of relatively fresh sewage, in some places, and the odors of sewage in the putrefactive condition.

Q. Did you say anything with reference to the suspended particles visible in the water?

A. There are suspended particles visible in the water.

Q. In marked degree?

A. At places; yes, sir.

Q. All along the shore front of New York City?

A. Quite generally.

Q. And how far out into the waters of the Bay did these marks extend?

A. I have seen them clearly across the rivers, one side to the other.

Q. Coming from the sewers in your judgment of New York City?

A. I could not answer that definitely. They may have come from the sewers from Jersey City, but the various sewer outlets are along the rivers at the shores.

Q. In your judgment the effect of the discharge of crude sewage from a population of approximately 5 million inhabitants is felt upon the whole waters of New York Bay?

A. I think it is.

Q. Including the waters along the shore front of the State

2201 of New Jersey?

A. I think it is. If I may qualify that—I am not quite clear as to the limits of the harbor outside, the Lower Bay, but I think the statement is correct even to that limit.

Q. Now, you have formed some conclusions upon estimates of population to be served by the proposed Passaic Valley District Sewer. What is the population as you understand it, at the present time to be served by the municipalities which have contracted with the Passaic Valley Sewerage Commissioners to build a sewer?

A. I do not know sir.

Q. What is the population that you have assumed in your testimony with reference to the effects of the construction and operation of the proposed sewer?

A. About 1,700,000 people in 1940.

Q. Yes.

A. And 702,400 in 1911.

Q. And in your judgment what percentage of the trade waste of the district are you calculating as a part of the sewage to be discharged through this sewer?

A. The whole of the trade waste as estimated by the Passaic Valley Sewerage Commissioners in their report of 1908.

Q. Well, do you know what percentage that was?

A. I do not remember, no, sir. In fact, I do not know, that it is given in the report.

Q. If, as a matter of fact, it appears that the trade waste to be discharged through this sewer is not to exceed 10 per cent of the whole trade waste of the district, would that affect in any way the conclusions that you have testified to?

A. I think not.

Q. So that the quantity of trade waste has no effect at all, in your judgment, upon the character of the discharge of sewage into New York Harbor?

A. I think it has an effect.

Q. Why would not the difference of 90 per cent affect the result in your judgment?

2202 A. Because the conclusions which I have reached have been based very largely upon my impression of what the sewage will be, coming from the communities which I understand will be connected up to this sewer. I have not taken into account any definite quantity of wastes in forming the opinion as to what the character of the sewage will be.

Q. Would not the quantity of trade wastes affect the quality of the sewage?

A. In this project, I think, while it might affect it somewhat, I think it will always be an industrial sewage, a sewage very largely influenced by industrial wastes. Of course, the quantity does have an effect, and without knowing the exact quantity of wastes and the exact quantity of sewage, it is not possible to state with precision, just what the character of the sewage will be.

Q. As an expert you would not be willing to say, would you that there is any practical difficulty in excluding trade wastes, from this sewer system?

A. I should expect there might be very great difficulty in excluding it.

Q. It is not impossible, however?

A. Under present municipal conditions, I should say it was clearly impossible.

Q. That is the imperfection of Municipal Government that causes you to reach that conclusion?

A. Not necessarily an imperfection.

Q. Now, what percentage or proportion of injurious effect upon

the waters of New York Harbor, in your opinion, will result from the discharge of the sewage from the proposed Passaic Valley District Sewer as compared with the discharge at a corresponding date of crude sewage from the sewers of Greater New York?

A. I have not formed any opinion on that subject.

Q. Can you form an opinion and testify to it?

A. Not without study. I have not given study to that question at all.

Q. Would you not be willing to testify in a general way as to the percentages or proportions?

A. No, sir, I would not.

Q. Would you expect a greater amount of deterioration re-
2203 sulting from the discharge of crude sewage from 5 million of inhabitants than from the discharge of a partially purified effluent of the sewage of 700,000 people?

A. I should.

Q. You would expect a very much larger deterioration would you not?

A. A much larger deterioration, yes, sir.

Q. And in all the elements of injury to the waters of the harbor?

A. So far as I know anything of them, yes, sir.

Q. A large depreciation in the dissolved oxygen?

A. Yes, sir.

Q. A larger amount of putrefying matter?

A. Yes, sir.

Q. A larger amount of foul and noxious odors?

A. Yes, sir.

Q. A greater amount of objectionable suspended matter?

A. Yes, sir.

Q. A greater amount of color, grease?

A. Yes, sir.

Q. Have you ever examined in detail a system of sewerage where the effluent is discharged under the conditions which are specified in the stipulation between the United States and the State of New Jersey?

A. Not under those exact conditions, no sir.

Q. Have you ever examined in detail the results of the discharge into a body of water corresponding in size and purity with the waters of New York Harbor, of sewage, at a depth of 40 feet below the surface?

A. Not a body of water corresponding exactly with New York Harbor.

Q. Do you know of any such system?

A. Not where the conditions are exactly alike.

Q. You have examined the exhibits in this case that have been offered by Complainants, in some detail?

A. I have.

Q. Have you in mind having seen among those exhibits the determination of oxygen in the waters at Robbins Reef practically complete. I mean by that, the standard amount in the water. Do you remember seeing the analysis of any such sample?

A. The standard amount in the water?

2204 Q. Yes, compared with sea water?

A. I do not know just what you mean by a standard amount in the water.

Q. What is the amount of oxygen that is understood to be contained in sea water?

A. The maximum amount is referred to at 100 per cent or complete saturation.

Q. Do not you remember a sample that showed that result, water taken from Robbins Reef?

A. I do not remember such a sample.

Q. If there is such a sample disclosed by the exhibits in this case, have you any explanation to make of it under the conditions that exist in the harbor?

A. I could not say without examining the conditions on the record. I do not know.

Q. From your observations of the water of the harbor, in your opinion, is it to some extent contaminated and polluted by sewage?

A. I should say it was.

Q. Throughout the whole body?

A. As I understand the limits of the harbor, yes, sir.

Q. Just state what you understand to be the limits of the harbor?

A. Including the Upper Bay and the Narrows, a short distance below the Narrows, the Hudson River, as far north as Mt. St. Vincent; the Harlem River and the East River into Throggs Neck.

Q. Now, if within a period of five years water taken from any point in the harbor as defined by you shows the maximum saturation of oxygen, how do you explain it, if the waters are polluted?

A. Well, it may be explained in several different ways. It may be due to a very large flow in the Hudson River, which would furnish so great a dilution as to maintain the full per cent of saturation of oxygen. It may have been due to a storm which would drive in a very large quantity of sea water. It may have happened that at that time, both of these causes were effective. It may have been the result of low temperature when the bacterial life

2205 and other organic life in the water was at very low ebb, so that the dissolved oxygen was not depleted, as would be the case at other seasons.

Q. Any one of those causes may be in operation at any particular time affecting the oxygen content of the waters of the harbor?

A. Yes, within limits. Of course the temperature condition would be confined to the cooler portion of the year.

Q. Now, is there any observable difference under the determination on the samples that have been submitted to you of the content of the oxygen at different depths in the waters of the harbor?

A. At places, there is, yes, sir.

Q. Do you know whether that is a normal difference or not?

A. It seems to me to be a logical difference, from which I would think that it would be normal.

Q. Is there in fact a normal difference of oxygen in waters at different depths, under the same conditions?

A. You mean the same condition as to depth and character of water?

Q. No, as to the character of the water. The same conditions as to winds and disturbance of the water?

A. That might be answered both ways, yes and no, if I understand your question.

Q. In the same body of water does the oxygen content vary at different depths?

A. It is likely to, yes, sir.

Q. And at what depth, if you know, does the oxygen disappear?

A. I do not think there is any established depth. It depends entirely upon local conditions, as in most cases probably it would not entirely disappear.

Q. Does it decrease as you increase the depth of the taking of the sample?

A. In some cases, it does, and in some cases it increases.

Q. Well, do you know whether in the waters of the harbor of New York, from the samples, determinations of samples that have been submitted to you, do you know whether the oxygen content decreases or increases as you go to greater depths?

2206 A. It does both.

Q. Do you know whether at Robbins Reef the oxygen content decreases or increases as you go to greater depth?

A. There is very little difference in samples that I have seen at Robbins Reef. I think the oxygen is lower at the surface. There is almost no difference in the samples taken July 12th and 13th.

Q. At what depths, different depths?

A. I shall have to refer to the original figures if you wish an exact answer. I think they are 1, 20 and 40 feet, judging from memory.

Q. And there is no difference at those depths, on those particular days?

A. No material difference at Robbins Reef. There may be a few per cent but very little.

Q. In your opinion is that the result of the pollution of the surface waters with sewage matters?

A. Not necessarily the surface waters alone. It is the result of the pollution of the surface waters in part.

Q. In your opinion is it due to the uniform pollution of the waters of the harbor at that point, to a depth of 40 feet?

A. In part, yes.

Q. It is in part due to the uniform pollution of the waters, that is what you mean?

A. Yes, sir.

Q. Well, now, you have testified that sewage has less specific gravity than the waters of the harbor?

A. Yes, sir.

Q. How do you account for the pollution of the waters at the depth of 40 feet if the sewage is lighter than the waters of the harbor?

A. Diffusion of the sewage through the waters of the harbor.

Q. And that diffusion takes place, does it, downward, notwithstanding the fact that the sewage is lighter than the water?

A. Yes, sir.

Q. And is uniform?

A. The sewage at Robbins Reef appears to be fairly uniformly distributed through the water.

Q. And that conclusion you arrive at from the presence
2207 of the oxygen at the different depths?

A. Yes, sir.

Q. Have you determined it in any other way?

A. By the other observations that have been put before me, but primarily the oxygen.

Q. What are the other observations put before you?

A. The currents and the topography and the various physical data which go to produce a thorough mixing of these waters. The fact that the water goes back and forth over a course of several miles and may be confined for a period of several days, that is an element which leads to that conclusion.

Q. Now, Mr. Eddy, assuming that the sewage that is discharged into the waters of New York Harbor is in fact of less specific gravity than the brackish waters of the harbor, what process is the cause of the diffusion in a practically uniform degree of the sewage at Robbins Reef to a depth of 40 feet in your judgment?

A. The physical process of diffusion of a liquid through another, aided very largely by the current, the wind, the tidal actions, and currents caused by the flow of the Hudson River, and undoubtedly the shipping may have some effect upon that. The passing to and fro of the boats, and the action of the propellors.

Q. In your opinion where does the sewage come from that pollutes the waters at Robbins Reef to a depth of 40 feet?

A. From the various sewer outlets which are located along the shore line of New York Harbor, and it is due to the sewage brought by the rivers as well.

Q. Now, these sewers that you have observed, all discharging sewage practically on the surface?

A. Either at or relatively near, I suppose some of them may be 10 or 12 feet deep.

Q. You suppose so, why do you suppose so?

A. Because I have seen them.

Q. Which ones?

A. The sewage of Clasons Point I think probably reached
2208 to a depth of 10 feet at high tide. I noticed several others which I presume I cannot mention by name.

Q. Now, taking this sewage so discharged, and being of a less specific gravity and therefore normally staying at the surface, is not that so; it would normally stay at the surface, would it not?

A. For a time, yes, not indefinitely.

Q. How long a time?

A. That depends entirely upon the conditions at the time. If the wind is blowing at a very high rate, there is tendency for it to become diffused through the water very much more rapidly than in a calm, and the currents at different points have an important influence upon it. I do not know that it would be possible to give

any definite time, although I should expect if the sewage were discharged in larger quantity and then the discharge stopped, then it would probably be in many places discernible for a period of half an hour to perhaps two hours.

Q. Is the process of diffusion of this litter or this sewage due to the less specific gravity than the waters of the harbor, is that a chemical process or a mechanical process?

A. I should call it a physical process. It is more likely to be a mechanical than chemical. It is not a chemical process.

Q. And if there was no agitation of the water, the liquid of less specific gravity would remain at the surface indefinitely?

A. No, sir, I think not.

Q. Why not?

A. Because of the natural diffusion of the lighter liquid through the heavier.

Q. That is a chemical law, is it, from your observation, the lighter liquid is diffused through the heavier underlying liquid?

A. It is, a physical law.

Q. And which process or what processes are, in your opinion responsible for the diffusion of the sewage to a depth of 40 feet in the waters of New York Harbor at Robbins Reef?

A. The natural tendency of the two liquids to diffuse, the action of the wind and of the tide and the currents, the shipping, the movement of the water.

2209 Q. And given a substantially continuous discharge of sewage matter at the surface, or practically at the surface, from the Greater City of New York, you think that those conditions which you have testified to account for the practical uniformity of the diffusion of sewage matter in the waters at Robbins Reef, do you?

A. Yes, sir.

Q. That by the time the sewage matter discharged from the sewers from Manhattan Island has proceeded as far out as Robbins Reef, it has become diffused uniformly to a depth of at least 40 feet in your opinion?

A. Undoubtedly in many cases; on many occasions, and I presume on most occasions.

Q. Have there been determinations that you have observed to indicate that?

A. Very largely, yes, sir.

Q. Now, you have testified as to your judgment of what will happen from the discharge of the Passaic Valley Trunk Sewer at Robbins Reef at a depth of 40 feet and under the conditions that are named in the stipulation between the United States and the State of New Jersey and the Passaic Valley Sewerage Commissioners. Won't you state that again? I do not care to have you read it; I would like to have you state in your own language?

A. May I refresh my memory as to what those conclusions were?

(The witness examines memorandum.)

I stated that the water in the immediate vicinity of the outlet will at times contain floating sewage matters.

Q. Well, at what point on the surface, with reference to the area of discharge at the depth of 40 feet will these floating particles be observable in your opinion?

A. At a great many different points.

Q. What will be the nearest point?

A. Directly over the outlet.

Q. In your judgment will the process of diffusion of the effluent discharged at the point indicated, be a considerable factor in the result?

A. In general it will; yes, sir.

2210 Q. Have you observed the operation of any sewerage system discharging an effluent of the character that is prescribed in the stipulation between the United States and the State of New Jersey, operating under somewhat similar conditions to those in New York Harbor?

A. No, sir. I never have seen an effluent that was exactly like that stipulated in that agreement.

Q. You never have seen such an effluent?

A. No, sir.

Q. Have you seen the effluent from any Imhoff system?

A. I have, yes, sir. I beg pardon. I do not think I have. I have studied so much. I do not think I have seen the effluent from an Imhoff tank.

Q. Have you not seen effluents that have been offered to you as drinking water?

A. I have seen them drink the effluent very foolishly, I think.

Q. Now, Mr. Eddy, you have given one of the phenomena which you will expect from the discharge of the sewage at Robbins Reef. What other is there?

A. Small particles of grease will be seen floating or suspended upon or in the water.

Q. And do you anticipate that this will create what is called, I think, a sleek field?

A. Not this itself. I refer to the particles of grease. The sleek field is rather a form which is indistinguishable as made up of particles.

Q. What other phenomena?

A. There will be oily sleek upon the surface of the water.

Q. Where will those be located?

A. Those will have their origin very close to the point of discharge, not probably directly over the point of discharge, because of the velocity of tidal currents, and the immediate origin will depend on that velocity, but they will extend in the direction of the tidal currents, unless driven to one side or the other by prevailing winds.

Q. Those exceptions are they or are they not borne out by your observations of the results of the examination of New York sewers at the present time?

A. It is borne out by my observations in New York and

2211 elsewhere.

Q. Where have you located sleek fields from the discharge of the sewage from the sewers of Manhattan Island?

A. Where did you say?
Q. Yes?
A. All along the East River are some of the most interesting, pretty well to the east, the one at Clasons Point I think was the one which interested me most, because of its very great extent.
Q. Are there many evident on the Hudson River shore?
A. They are not as noticeable there, but they are noticeable, you can see them, but the current, when I happened to be there, had been very swift, which tends to break them up more or less. They are not as noticeable as at Clasons Point.
Q. Where have you noticed any sleek fields along the Hudson River Shore of the Island of Manhattan?
A. Along the slips. I have not made any notes as to any particular ones.
Q. You mean within the slips?
A. They did extend in the slips and without as well.
Q. Where?
A. Directly out from the slips.
Q. What slips?
A. I could not give the name or the number.
Q. Cannot you designate any particular one?
A. I could not.
Q. You have been about the Hudson River Shore of the Island of Manhattan, more or less for some years, have you not, at times?
A. Yes, sir.
Q. Are these sleek fields noticeable; were they at that time?
A. I think that I have noticed them when crossing in ferry boats. I could not give the date or the exact location or the size of them.
Q. Have you ever had occasion to observe the pollution of the waters within the slips on the Hudson River shore of the Island of Manhattan from sewage?
A. I have observed that at times. I have not made any study of it.
2211½ Q. Is it not noticeable?
A. It was. I have noticed it down around the Battery. I do not know as I can call that a slip. There were interferences in the flow of the river, which *the* made the situation very similar to the slips.
Q. And did you observe or trace the discharge of sewers from the Island of Manhattan, directly into the slips?
A. I did not.
Q. You do not know whether they were discharging there directly or not?
A. I do not, except that I saw the evidences of sewage which were in the water from the Hudson River side.
Q. Well, on the East River side have you observed the same conditions?
A. I have, and actually saw the sewage discharging.
Q. And that has been going on to your knowledge for some time?
A. I think so.

Q. What other phenomena are you led to expect in your expert opinion.

A. At times I should expect considerable coloring matter in the water, in and about the outlets.

Q. Due to what?

A. Due to the industrial wastes of the Passaic Valley Industries. Due to the putrefactive conditions of the sewage in hot weather, and in cold weather, and in spring due to the milky dirty appearance of the sewage, which may not then be in putrefactive condition, and especially due to the discharge of storm water, which makes a very dirty muddy appearance. Under those conditions.

Q. Well, those conditions, will they, in your judgment, be any more noticeable or any more objectionable than the conditions observed by you to be produced along the shores of the Island of Manhattan from the discharge of the local sewers?

A. I think not.

Q. As much so?

A. Probably as much so, and I would like to qualify my previous answer. In some cases where the discharge from Manhattan
2212 Island is very small, I think this might be more objectionable, but I thought you meant in a general way, gallon for gallon.

Q. Will you expect any greater result in this direction from the operation of the Passaic Valley Sewer, than those that are observed from the average flow of the sewers from the Island of Manhattan?

A. Not gallon for gallon, under similar conditions.

Q. Gallon for gallon you would not expect a great deal less?

A. Not in this district, no sir. Not as to particles and coloring matters.

Q. You are keeping in mind, are you, the fact that the proposal, as you understand it, involves a partical purification?

A. Yes, sir.

Q. And the sewage of the City of New York, the Island of Manhattan, is not purified at all?

A. Yes, sir.

Q. And bearing in mind that the sewage from the Island of Manhattan is storm water as well as house sewage and industrial wastes?

A. Yes.

Q. And you expect that the sewage discharged at Robbins Reef from the Passaic Valley sewer, under the conditions of the proposal at a depth of 40 feet, gallon for gallon, will produce as much result in the way that you are now testifying as the sewers of the City of New York from the Island of Manhattan?

A. I think practically so.

Q. Then in your opinion it makes no difference whether the sewage is partially purified or not?

A. Not so far as the coloring matter is concerned. The means for purification do not involve the removal of coloring matter to any extent.

Q. And it makes no difference whether or not sewage is discharged at a depth of 40 feet, or at the surface?

A. Under this condition, I think it would not, so far as the coloring matter was concerned.

2213 Q. Now, will you explain why you reached that conclusion?

A. The quantity of sewage discharged at this point is so great that I think it will hold its integrity until it reaches the surface, and after having reached the surface, the color will be evident as though it were discharged on the surface.

Q. That is the reason, is it?

A. Yes, sir.

Q. You do not expect then that the sewage discharged over an area of 3 acres at a depth of 40 feet would be at all diluted?

A. I do expect that it will be diluted; yes, sir.

Q. To what extent will it be diluted?

A. That is very difficult to say. Probably different at different depths.

Q. Is it not necessary to determine the extent of the dilution before you can venture to testify as to the effect of this sewage discharge upon the appearances at surface, with reference to color?

A. I do not know that it is in exact figures.

Q. But, even roughly?

A. I do not know that it is.

Q. Now, what other phenomena do you anticipate, in the exercise of your judgment as an expert, will result from the proposed Passaic Valley sewage discharged as you understand it?

A. It will increase the turbidity in the water. Give to it a milky and dirty appearance when the sewage is fresh.

Q. How does that differ from the last phenomenon that you have testified to?

A. That turbidity is caused by very finely suspended matter as distinguished from the matters which generally cause the color, in many cases cause the color, known as matter in solution.

Q. How do you determine that there is turbidity?

A. It is obvious to the eye.

Q. It is color, is it not?

A. No.

Q. Has no color?

A. It may have color, or it may not. I suppose it has a color, although we do not speak of it as color usually. It is the milky condition, the opaque appearance. Turbidity may be brown, it

2214 may be whitish, or it may be without color that you would distinguish by name as such.

Q. And still you could distinguish it by the eye, notwithstanding it had no color?

A. Yes, sir, no marked color.

Q. Is turbidity due to any other causes than the one that would produce color?

A. Well, it is due to suspended matter.

Q. To what is color due in the water.

A. Due to matters in solution.

Q. Not to suspended matter?

A. It may be due to matter in suspension as I pointed out before.

Q. What other phenomenon do you expect under the operation of the Passaic Valley Sewer, under the conditions as you understand them?

A. There will be a deposit of more or less of the suspended matter escaping from the basins in the effluents, some of which will be relatively coarse matter, much of it will be fine.

Q. Where will these deposits be observable?

A. On the bed of the harbor.

Q. On the bed of the harbor?

A. Yes, sir.

Q. How are you going to determine those?

A. They are determined by securing samples by boring.

Q. Is there any other way of determining them?

A. On the shores where the water is not deep you might be able to see them through the water. Stir them up.

Q. You expect there will be deposits from this proposed discharge at Robbins Reef on the shores?

A. I think there may be.

Q. Well, what shores?

A. Any of the shores of the harbor.

Q. And they will result from the fact that the material that is so deposited has been light enough to reach the surface of the water?

A. Not necessarily. It may be carried along by the currents. It may never reach the surface.

Q. But, it will rise by the action of the currents above the depth of 40 feet below the surface?

A. I do not understand.

Q. This material, this sewage, which you understand is to be discharged at a depth of 40 feet?

A. Yes, sir.

2215 Q. Will these deposits that you have testified to be observable at a depth of less than 40 feet at any point?

A. Undoubtedly.

Q. And how will that happen, having been discharged at a depth of 40 feet. How do you account for their being deposited.

A. Being carried by the water.

Q. You mean raised?

A. Raised, carried horizontally, both.

Q. And removed vertically?

A. Yes, sir.

Q. You think it will be lighter than the water into which it is discharged?

A. Not necessarily.

Q. What percentage of the solid matter in your judgment, will be deposited at a point above 40 feet below the surface of the water?

A. I have not formed any figures on that.

Q. Cannot you form any opinion?

A. Not without giving it special study.

Q. Have you given any study to that subject?

A. I have not to that particular phase of the subject.

Q. Now, speaking from your judgment as an expert, do you think any considerable part of the matters that will be deposited will be deposited above a point 40 feet below the surface of the water?

A. I should say yes.

Q. What other phenomenon are you anticipating?

A. The quantity of organic matter in sewage discharged from these outlets will be very great, and cause rapid diminution in the supply of dissolved oxygen in the waters of the harbor.

Q. Where, if you know, is the sewage now discharged, which it is proposed to discharge at Robbins Reef?

A. So far as my knowledge goes, it is discharged very largely into the Passaic River.

Q. Do you know where the Passaic River empties?

A. I do.

Q. Where?

A. Into Newark Bay.

Q. And that is connected with what body of water?

A. The Arthur Kill and Kill van Kull.

2216 Q. Have you made any study of the waters of Newark Bay?

A. I have.

Q. With a view to determining the oxygen content?

A. Yes, sir.

Q. Well, what results did you reach in the study of the water of New York Bay in that respect?

A. I found there was oxygen present in the waters of Newark Bay.

Q. As large a percentage as in the waters of New York Bay?

A. It depends on what portion of New York Bay you make compari-ons with, what portion of Newark Bay.

Q. Newark Bay differs in different portions?

A. Yes, but I do not remember the figures at this moment.

Q. Take the waters of New York Bay as a whole, does the content of oxygen as disclosed by the determinations submitted to you, indicate the decrease of that oxygen in those waters to an alarming extent?

A. In New York Bay?

Q. In Newark Bay?

A. In Newark Bay, I think the indications are that oxygen is reduced to an alarming extent at times.

Q. Well, now, do you know, whether the conditions of the water of Newark Bay appear by actual examination and experiment to affect the waters of New York Bay?

A. I should say they did.

Q. Do you know whether they do?

A. That is my opinion, after looking over the dissolved oxygen results.

Q. You say that you have read the testimony of other witnesses in this case?

A. I have read some of it.

Q. Do you remember reading the testimony of Mr. Tribus?

A. I do not; no, sir.

Q. You do not recall that there are no evidences of pollution of the waters of New York Harbor from the waters of New York Bay in the testimony of some of the witnesses for the complainants?

A. I do not.

Q. You do not know except from your interpretation of the results of the determinations of oxygen, whether or not these waters do affect the pollution of the waters of New York Bay?

2217 A. I think I know it from other causes.

Q. How?

A. The physical conditions make it self evident that these waters do affect the water of New York Bay.

Q. What are those physical conditions?

A. The fact that the sewage of the Passaic Valley is discharged into the Passaic River, the oxygen is depleted, and the water with the depleted oxygen passes through the Bay and comes out into New York Bay. All those facts show that the water from Newark Bay does have an effect upon the pollution of New York Harbor. It tends to increase it.

At 1 P. M. adjourned for noon recess until 2 P. M.

2218 CORPORATION COUNSEL'S OFFICE,
June 18th, 1912—Afternoon Session, 2 p. m.

HARRISON P. EDDY, a witness called on behalf of complainants, recalled, for further examination, testified as follows:

Cross-examination by Mr. Riker (resumed):

Q. At recess, Mr. Eddy, we were inquiring as to the effect of the pollution of Newark Bay, upon the waters of the harbor of New York. I think that you said undoubtedly the pollution of Newark Bay affected New York Bay water. To any extent, in your opinion?

A. I think so, yes, sir.

Q. And the organic matter that is discharged into New York Bay from Newark Bay, is it in the state of decomposition, in your judgment?

A. Undoubtedly.

Q. Has it been some time on the way?

A. Yes, sir.

Q. And been subjected to septic influences of one sort and another?

A. At a good many times, at seasons of the year, that is undoubtedly true.

Q. Chiefly in the season when the temperature is high?

A. The septic action is greater then.

Q. And those discharges into the waters of New York Bay are in a highly objectionable condition?

A. I do not think that is shown by the analyses, being highly objectionable. Of course, just what you mean by that term is difficult to interpret.

Q. In what condition do you think it is discharged into New York Bay?

A. It is more or less oxidized. There is oxygen present in the Newark Bay water at the end, near the Kill van Kull, at all times, so far as I have seen from the analyses.

Q. But the organic matter that finds its way into New York Bay from Newark Bay, in your opnion, is it in a state of decomposition?

A. It is.

Q. Well, insofar as this project will result in the removal of that source of pollution from the waters of New York Bay, it is
2219 a desirable one, is it not?

A. I think it would add to it, rather than result in the removal of it.

Q. Well, I know, but the taking away of that particular method of polluting the waters of New York Bay, would be an improvement to the waters of New York Bay, if it was not replaced by something equally objectionable?

A. I think that is true.

Q. How extensive is the pollution of the waters of New York Bay, in your judgment, from the data that has been submitted to you from the waters of Newark Bay?

A. The waters which enter New York Bay from Newark Bay are in a condition which is quite similar to that of the water of New York Bay. Instead of having the advantage of the clean water which was originally provided by nature, it is very much depleted in oxygen, and carries more or less organic matter. I do not know, it would be impossible to say, to what extent that is effective in reducing the oxygen in New York Bay. Undoubtedly it plays an important part.

Q. And, of course, when nature provided this fund of unpolluted water from Newark Bay, it also provided a practically unpolluted body of water in New York Bay?

A. I presume that condition may have existed at one time.

Q. In forming your judgment in regard to the results of the discharge of the proposed sewer from the Passaic Valley into New York Bay, what data have you used, so far as the project itself is concerned?

A. The data given in the original report of the Passaic Valley Sewerage Commissioners, dated, I think, 1908, and the data contained in the stipulation between the United States Government and the Passaic Valley Sewerage Commissioners.

Q. That is Exhibit No. 135 for Complainants?

A. Yes, sir.

Q. That is one that you refer to?

A. Yes, sir.

Q. And you have that under consideration as part of the data?

A. I have, yes, sir.

Q. Is that later in date than the report of the commissioners which you referred to; is this stipulation later in date than the re-
2220 port of the commissioners which you have referred to?

A. I have no knowledge as to the date except as it was stated when it was filed, presumably in the Supreme Court of the United States, October Term, 1909. I think that is the only date which I have.

Q. The instrument is incomplete as to the date?

A. I never have had the date of the instrument I think.

Q. Have you made any investigation to discover whether or not the plans of the Passaic Valley Sewerage Commissioners have been in any way modified or changed subsequent to and in view of this stipulation, which you have before you?

A. I have not.

Q. Why not, Mr. Eddy?

A. I have had no instructions to do so from counsel. No data has been furnished to me by counsel.

Q. Have you made a study of bacteriology to any extent?

A. I have to some extent, yes, sir.

Q. In connection with your sewerage work?

A. Yes, sir.

Q. And did you specialize also on water supply?

A. To some extent. My partner does rather more of the water work than I do.

Q. It is in connection with that work that you have made your studies of bacteriology?

A. My studies have been made more particularly in connection with the disposal of sewage. We did a great deal of bacteriological work in the laboratory at Worcester; some at Gloversville, and I have followed that work from year to year.

Q. Now, you have testified to a minimum amount of dissolved oxygen in the waters of New York Bay as being safe?

A. Yes, sir.

Q. And that I think you said was 50 per cent?

A. Place that 3 c. c. per litre, which is practically 50% saturation value?

Q. Do you say that below that is a dangerous condition?

A. From some points of view, yes.

Q. From what points of view is reduction below that point
2221 dangerous?

A. Where the water is allowed to get below 50% saturation, the water which enters the slips and creeks where it is not readily renewed, will be subject to decomposition, and may on account of the pollution in mud deposits create offensive conditions.. In my judgment it ought to be the aim to keep the waters throughout the bay at least 50 per cent saturation, the average for one week, during hot weather.

Q. When you speak of hot weather, just what do you mean?

A. During the warm summer season. Take a year like last year for example. I think the water ought not to fall below 50 per cent under those conditions.

Q. Then, when the mean temperature is above some specified degree of heat, you think it is dangerous to have the degree of saturation less than 50 per cent?

A. It would be rather difficult to apply it in that way, because the mean temperature during the week in question may not be the important factor in reducing the oxygen. That is, the oxygen may be reduced as the effect of prior higher temperature.

Q. I did not use the word "week," I said period of time?

A. I do not think it would be practicable to fix on a definite temperature.

Q. You would not undertake to fix any definite temperature?

A. I certainly would not without further study on that subject.

Q. And the danger, as I take it, is it or is it not one that arises from the putrefaction of the organic matters in the piers and slips and creeks that you refer to?

A. That is one of the factors. The decomposition of the sewage which might not be termed putrefaction is also a factor.

Q. *Is* the decomposion of the sewage under those conditions what is the danger?

A. The oxygen is reduced by the decomposition.

Q. What other change is there?

A. That is the primary danger, under conditions when oxygen is present.

2222 Q. What secondary danger is there?

A. The effect on fish life is prejudicial. In order to maintain a suitable equilibrium of life in the waters it is necessary to have the supply of oxygen.

Q. That is a secondary danger; what other secondary dangers are there?

A. From the decomposition you mean alone, or from reducing the water below 50 per cent.?

Q. From the decomposition of organic matter?

A. That is the only one that I think of at the present moment.

Q. Is the depletion of the oxygen supply in the water—has that a consequent effect upon animal life in the water?

A. Yes, sir.

Q. And no other that you can think of?

A. I think that is all.

Q. Does that percentage of oxygen apply to fresh water as well as to waters of the harbor, like New York Harbor?

A. Not necessarily. It might under some conditions, but under other conditions it might not.

Q. What are the conditions, the other conditions that you refer to, to which it does not apply?

A. Well, in the case of a stream, for example, where all the water is running rapidly away all the while, it is flowing over dams. There the oxygen may be for a very short space or period of time reduced quite low, and then after it falls over the dam, it is greatly increased. In some rivers where the oxygen was reduced in the ponds it was then increased, almost to saturation by falling over the dams. Those conditions are quite different from what you get here.

Q. And the saturation of water with oxygen is a mechanical process, is it not?

A. Well, it is done by mechanical means.

Q. Take the Ohio River into which the sewage of Louisville was discharged under your plan; is that a condition, in which

2223 the oxygen if reduced below 50 per cent. is a dangerous one?

A. I should think that it would be in that case.

Q. It would not be dangerous?

A. I should think it would not. That water is moving along very rapidly, and undoubtedly the oxygen would return very quickly to the water.

Q. And the organic matter would be rapidly decomposed or rendered innocuous by the oxygen coming in?

A. It is rendered innocuous in that way, and a great deal is deposited in the bed of the stream.

Q. Along the banks?

A. More or less along the banks, I presume. That is washed out apparently, at times of high water.

Q. And carried down the stream until it is finally rendered stable by chemical changes?

A. I presume it is.

Q. Did you make any special study of it?

A. I did not; no, sir.

Q. So that the proposed discharge from the Passaic Valley Sewer with reference to the oxygen content of the waters of New York Harbor, has an important effect upon the safety of the water in the respects in which you have testified?

A. It has an effect in those respects. There may be others.

Q. What others?

A. I do not think of any others at the present moment.

Q. So far as you think of then, that is all?

A. Yes, sir.

Q. Is it a desirable thing to discharge sewage at a considerable depth below the surface of the water as compared with a surface discharge?

A. In some cases I think it is.

Q. And not all?

A. Not necessarily.

Q. Given the same amount of discharge and of the same quality in your opinion is it desirable to discharge it, so far as its effect upon the surrounding waters is concerned at a depth or at the surface of the water?

A. In general I should say at a depth.

2224 Q. And the greater the depth, the more desirable?

A. I should expect that to be the case.

Q. Have you made any special study of the results of the discharge of sewage into the harbor waters in large quantities at considerable depths?

A. I have made numerous inspections of the Boston outlets.

Q. And for the purpose of observing what particular phenomena?

A. The various phenomena connected with disposal, diffusion, the effect of the sewage on the waters.

Q. The diffusion and the effect on the surface of the waters, what else?

A. I think that that covers the field.

Q. With reference to the diffusion, what were your observations?

A. Taking the oldest outlet first, used at Moon Island, the discharge of the sewage is on the ebb tide and very large sewage fields

art created, and very large sleek fields, and there is at times quite an offensive odor, and the discharge of that sewage is at or near the surface.

I do not know the elevation of the bottom of the sewer, but I should presume it might be in the neighborhood of 10 feet below high tide, and perhaps, when the discharge ceases, the bottom of the sewer would be in the neighborhood of 5 to 7 feet below the surface of the water.

Q. That is your observation, I suppose?

A. That is from observation only, not from measurements.

Q. What other tests of the diffusion did you make other than the ones that you have now testified to?

A. I made no other tests.

Q. You made no tests?

A. No, sir.

Q. You would not call that a test at all?

A. No, sir.

Q. There are other tests that could be applied, are there not?

A. There are.

Q. Now, what other observations have you made in Boston Harbor?

A. I observed the discharge of sewage from the Deer Island
2225 outlet of the North Metropolitan system a number of times. There the pipe is very close to the surface of the water at low tide and about 10 feet deep at high tide. A very distinct large sewage field was created. There is evidence of considerable floating matter. There are odors given off from the water, and there is also a very large sleek field.

Q. And did you make any tests here for the diffusion of the sewage?

A. I did not.

Q. What other observations did you make?

A. The discharge of sewage from the Nutt Island, or Peddocks Island outlet in Boston. There I think the pipe—there are two of them there, one only in use—is about 25 feet below low tide; about 35 feet below high tide, and here the effect of the discharge is very obvious. There is a sewage field and a sleek field; suspended matter is visable in the water.

Q. Did you make any tests for diffusion here?

A. I did not.

Q. Now, taking the Moon Island discharge; did you examine into what, if any means of purification were applied to that sewage?

A. I know the system through which the sewage is collected and discharged, so that I know what means there are, not because I have looked into it particularly, but I have observed it. The sewage is screened before being pumped, and it passes through a deposit sewer, somewhat similar to grit chambers, or a sewer which will accomplish work somewhat similar to that accomplished by grit chambers. It then passes into storage basins, where it is stored until it is discharged.

Q. You made a study of these means of purification used in Boston Harbor, at the Moon Island outlet?

A. By observation; yes, sir.

Q. Now, taking Deer Island; do you know what means are used to purify the sewage discharged there, if any?

A. I think screening is the only means for effecting a change.

2226 Q. What kind of screening?

A. Screening by means of rack screens, relatively coarse screens.

Q. Corresponding in any way with the first process specified in the stipulation between the United States and the State of New Jersey?

A. I should say in a general way, yes, sir.

Q. Any other means of purification?

A. That is all that I know of.

Q. The Nutt Island discharge, the Peddocks Island discharge, what are the means used there for partial purification of the sewage?

A. Screening is the only means I know of.

Q. The same kind as at Deer Island?

A. Very similar to that; yes, sir.

Q. Do you know of any sewage discharge into the harbor waters or sea waters which had been subjected to means of purification equal to those that are specified in the stipulation between the United States, the State of New Jersey and the Passaic Valley Sewerage Commissioners?

A. Yes, sir.

Q. Where?

A. Providence, Rhode Island.

Q. And where does that discharge?

A. Into the Providence River.

Q. Is it of the same type of purification or less or greater?

A. Greater, I should say.

Q. Is there any other that you know of?

A. That is the only one that I think of at the present time.

Q. When was that installed?

A. I beg pardon, I ought to mention the London plant which I visited several times.

Q. In London?

A. Yes.

Q. Where does that discharge?

A. Into the Thames River.

Q. You do not class the Thames with New York Harbor, do you?

A. Except that it is a tidal stream. No, it is not closely similar to it, of course.

2227 Q. What other ones have you had under your observation where means of purification equal to those contained in the stipulation are provided for the sewage, before it is discharged into the harbor water?

A. That is all I think of at the present moment.

Q. And, as a matter of fact, there is no one of the two or three

that you have mentioned which discharged the effluent under the conditions which are provided for in this stipulation, is there?

A. No, sir.

Q. Now, Mr. Eddy, if in passing the discharge from the Passaic Valley District sewer into New York Bay it contains no visable suspended particles, and does not produce objectionable deposits, and does not produce odors as the result of the putrefaction of organic matters contained in the sewage, and does not cause any grease or color to appear on the surface of the waters, in your opinion is that discharge objectionable?

A. I should thing it would be.

Q. In what respect?

A. Because it greatly increases the quantity of dissolved organic matter which will result in reducing the oxygen content of the harbor waters.

Q. And with what result, what objectionable result?

A. With the result of causing the waters to be so low in dissolved oxygen that putrefaction is likely to take place in the slips.

Q. From the discharge of the sewage of New York City?

A. That is also a factor, of course.

Q. It will reduce, in your opinion, the sewage digestive capacity of the harbor?

A. I think it will.

Q. Will it produce any other bad effect?

A. It may increase the danger to bathing; the danger to taking shell fish in certain localities.

Q. Anything else?

A. It will cause an objectionable appearance of the water.

Q. Are you remembering that the supposition involves
2228 that there will be no grease or color due to the discharge?

A. Yes.

Q. And you still think it may produce visable semblances that will be objectionable?

A. The turbidity would be very marked. I do not think that that was included in your question.

Q. Not turbidity, but color was?

A. Turbidity was not.

Q. Bearing in mind there is to be no color visible, you still think that it may be objectionable from that point of view?

A. I do.

Q. That the turbidity will be distinguishable where there is no color?

A. I think so, in the sense that we ordinarily use the term color.

Q. Will you define what you mean by color?

A. I mean color that is imparted by the sewage, a distinct red or black or green color. Simply a muddy dirty appearance I do not class as color. That would come from turbidity.

Q. You are restricting your definition of color in connection with sewage matter, are you?

A. The practical consideration of it.

Q. And confined to sewage matters, not color in general?

A. Yes, confined to the questions at issue, yes, sir.

Q. In your opinion, is it practicable to adopt arrangements which will produce an effluent of the kind that I have described?

A. I think there are means which would produce an effluent, which, if discharged into the bay, would comply with these first four specifications, which I think you read.

Q. Do you intend that in connection with the point of the proposed discharge and the depth of the discharge?

A. That is what I take into consideration, yes, sir.

Q. Do you think it is practicable to produce that result?

A. I do.

Q. Now, when you say that you have taken into consideration the proposal that is embodied in this stipulation, have you in
2229 in fact taken into consideration the part of the second general paragraph which provides that the Passaic Valley Sewerage Commissioners agree with the United States that in the operation of said sewer system at all times the following results shall be secured, either through complainance with the requirements of the immediate preceding paragraphs, or through other require- lawful additional arrangements? Have you taken into consideration the last clause that I have just read?

A. I have considered it, but I have not based my answer on any works other than those stipulated in this agreement.

Q. Did you exclude from your mind as part of the proposal of the Passaic Valley Sewerage Commissioners the adoption of any arrangements which would produce the effluent required, if the specified arrangements do not produce that result?

A. To the extent that I have based my answers upon the specified works.

Mr. Riker: I think that is all.

Redirect examination by Mr. O'Sullivan:

Q. What method known to engineers would remove visable suspended particles from sewage short of filtration?

A. Screenings, sedimentation, chemical precipitation, various kinds of straining and filtration, will all remove visable suspended matters.

Q. Is any provision made for filtration in Complainants' Exhibit No. 135?

A. No specific filtration.

Q. Will any method short of filtration guarantee the stipulations as results?

A. I think not.

Q. I understood you to answer Mr. Riker, Mr. Eddy, that you had observed the Passaic River and Newark Bay in your observations and studies relative to the Passaic River. Can you state what the condition of the sewage discharged into that river was, at the time
2230 of your observations as to its septic or other character?

A. I cannot.

Q. I direct your attention, Mr. Eddy, to Complainants' Exhibit

No. 133, and direct your attention on that chart or map to the figures at the inlet of Newark Bay at the bottom of the point in conjunction with those between the Hudson River and New York Bay, and I ask you how they compare?

A. The per cent. of saturation at the inlet to Newark Bay, if by that you mean the lower end of Newark Bay, near the Kill van Kull.

Q. Yes.

A. Is 64%. The per cent. of saturation at the mouth of the Hudson is 55.

Q. So that the oxygen content would be greatest at which point?

A. The oxygen content was greater at the point in Newark Bay.

Q. Are you familiar with the length of time it takes sewage to get out of the Passaic River?

A. Only in a general way due to my observations. I have made no measurements or calculations.

Mr. O'Sullivan: I think that is all.

Recross-examination by Mr. Riker:

Q. Mr. Eddy, your attention has been directed to plate, Figure 6, that you have before you. How do you account for the reduced oxygen at the mouth of the Hudson River?

A. I think it is due to the effect of the decomposition of sewage and sewage matters.

Q. Discharged from what?

A. Either in the water or in the mud below, discharged from the sewers tributary to the waters of the Hudson, the Upper Bay, Newark Bay, Passaic River and East River. All of the sewage which comes in contact with these waters and also doubtless sewage discharged into the Hudson River, somewheres up above the City.

Q. Well, I observe upon the river there is an indication of an average of 78 per cent?

A. Yes, sir.

Q. So that that indicates the amount of reduction in the
2231 free oxygen at that point, does it not?

A. 78 per cent. yes, sir, at that time.

Q. So that the falling off of 23 per cent. from that point to the mouth of the river is due to polluting sources below that point probably?

A. Below the upper point you mean?

Q. Yes? And that is Mt. St. Vincent, is it not?

A. I think it is, yes, sir, in part, although, of course the reduction of oxygen that has taken place in the water above this point, has its influence on the water below. That is, if it started at 78, if the water passing at that point is 78, and then it is reduced to 55, it would be only from 78 to 55, and not from 100.

Q. 78 to 55, that is what I asked you, whether the reduction was due to pollution between those two points probably?

A. Not necessarily between those two points, because this 55 undoubtedly influences the water that comes up the Hudson, but does not get up as far as 78; it may have come from the Upper Bay or the

East River. It does not necessarily mean the direct discharge of sewage between those two points alone.

Q. It may mean that the sewage had been discharged at some point below and worked its way up?

A. Yes, sir.

Q. The lowest percentage you see here, is at the mouth of the East River 54 per cent?

A. Yes, sir.

Q. You think it comes from there, perhaps?

A. That same water which is found at times in the lower reaches of the Hudson may come in part from the East River and Upper Bay.

Q. You would not expect waters where the percentage was 72, 74, or 78 to be instrumental in producing 75 per cent. at the mouth of the river?

A. Of course the water which comes from the point where it is 72, at Robbins Reef, goes up the Hudson, receives sewage on its
2232 way, and it may be influential, that sewage may be influential in causing a reduction to 55.

Q. In the main is it not your opinion, or is it, that the indicated percentage of 54 at the mouth of the East River and 55 at the mouth of the Hudson River are the result of sewage discharged from the Island of Manhattan and Brooklyn?

A. Only in part. The sewage discharged from the Jersey shore is effective.

Q. To what extent, in your opinion?

A. I cannot say to what extent. I do not know what per cent. of reduction it would cause.

Redirect examination by Mr. O'Sullivan:

Q. Mr. Eddy, in the lower Hudson and on the west side of New York Bay is sewage received from riparian communities in the State of New Jersey?

A. I think it is.

Q. And contributes to the reduction of the oxygen that your attention has been directed to?

A. I believe it does.

Recross-examination by Mr. Riker:

Q. Have you ever made any tests or have any tests been submitted to you to determine whether or not the sewage from those New Jersey riparian towns as a matter of fact is carried up to the mouth of the Hudson River?

A. I never made any tests. I have observed a large number of float experiments which would indicate that it certainly would be.

Q. Float experiments along the New Jersey shore?

A. Some of them, I think did go in toward New Jersey.

Q. What do you mean by toward the New Jersey shore?

A. From the center of the stream in toward the Jersey shore line

Q. How near the New Jersey shore was any float observation made that was made under your observation?

A. I could not give you the exact distance. As I remember, they came fairly colse to the pier head line, some of them.

2233 Q. Having enough recollection of them to say fairly close, cannot you tell what you mean by "fairly" in distance?

A. I should think possibly it might have been within 150 or 250 feet perhaps of the pierhead lines, some of them.

Mr. Riker: That is all.

Mr. O'Sullivan: That is all, Mr. Eddy. Are you through with the witness?

Mr. Riker: Yes, that is all.

Adjourned to June 19th, 1912 at 10:30 A. M.

2234 Supreme Court of the United States, October Term, 1911.

THE PEOPLE OF THE STATE OF NEW YORK, Complainants,
against
STATE OF NEW JERSEY AND PASSAIC VALLEY SEWERAGE COMMISSIONERS, Defendants.

Corporation Counsel's Office,
New York City, June 19th, 1912, 10:30 a. m.

Before:

James D. Maher, Esq., Commissioner.

Appearances:

Dr. William J. O'Sullivan, Special Counsel for the People of the State of New York, Complainants.

Adrian Riker, Esq., of Counsel for the Passaic Valley Sewerage Commissioners, Defendants.

Met pursuant to adjournment.

DESMOND FITZ GERALD, a witness called on behalf of Complainants, being first duly sworn, testified as follows:

Direct examination by Mr. O'Sullivan:

Q. What is your full name?

A. Desmond Fitz Gerald.

Q. What is your present occupation or vocation?

A. Consulting engineer.

Q. Will you state to what municipalities and institutions you hold any relationship as Engineer, whether Consultant or otherwise?

A. I have just finished a report for the Town of Manchester, Massachusetts, on its sewerage system. I am at present a member of the commission for abolishing grade crossing at Belmont. I am a Member of the Corporation of the Institute of Technology at Boston. I

am Chairman of the Park Commissioners of Brookline and
2235 Trustee of the Public Library at Brookline.

Q. What offices have you held in the past as an engineer?

—. I have had the honor of being President of the American Society of Civil Engineers, President of Boston Society of Civil Engineers, President Of New England Water Works Association, Chairman Massachusetts Topographical Survey Commission, Commissioner to establish the boundary line between New York and Massachusetts, Commissioner to establish the boundary line between Rhode Island and Massachusetts, Commission for designing water and sewerage works for the City of Manila, Philippine Islands, Commissioner for the water supply tunnel for the City of Washington, D. C., Commissioner for establishing water supply and sewerage works for the City of Cleveland, Ohio, Commissioner on Metropolitan improvements for the State of Massachusetts.

Q. What is the proper title of that commission?

A. The Metropolitan Improvement Commission.

Q. For the State of Massachusetts?

A. For the State of Massachusetts.

Q. Now, I will ask you to go back a litle bit, Mr. Fitz Gerald. In 1868 were you a Civil Engineer?

A. I began my professional career before 1868, but in 1868 I was an engineer on a western railroad, the Indianapolis and Vincennes Railroad, and I practically began my professional work for myself about that time, perhaps a year earlier.

Q. In 1869, you were still practicing as a Civil Engineer?

Q. Yes, in 1869 I was on the Cairo and Vincennes Railroad. Later I became engineer for the Boston and Albany Railroad. Then I went into sanitary engineering after that.

Q. Were you ever connected with the Rockford, Rock Island & St. Louis Railroad?

A. Yes, civil engineer on that road.

Q. In what year?

A. In 1869.

Q. In your capacity as Civil Engineer, during that same year, were you called upon in relation to any improvement of the
2236 Osage River in Missouri?

A. Yes, I was called in by the government to make a survey and report on the Osage River in Missouri, with reference to improving it for navigation.

Q. What government?

A. The Federal Government.

Q. Now take 1870 to 1873?

A. At that time I was engineer for the Boston & Albany Railroad.

Q. Civil Engineer?

A. Yes.

Q. Now, 1873 to 1898?

A. I was from 1873 to 1898 Resident Engineer and Superintendent in Boston of the Water Works.

Q. Take 1898 to 1903?

A. I was Department Engineer for the Metropolitan Water Supply.

Q. And 1903 to 1908?

A. I was Consulting Engineer on some works for the City of San Francisco, California.

Q. Have you acted as Consulting Engineer for any sanitary works in cities and towns?

A. I have.

Q. Have you been employed to give expert testimony in many cases in court?

A. Yes, very many cases in court.

Q. Involving much money?

A. Involving large sums.

Q. Any important interests?

A. Yes.

Q. Now, coming to water supplies and sewage disposal matters of that kind. When did you begin doing any work on purification of water supplies?

A. Very early in my professional experience I was brought into connection with works necessary for the purification of public water supplies, and, owing to my official connection with works for the supply of the city of Boston with pure water, I became impressed with the necessity for the establishment of purification plants on the water sheds for the purification of sewage which under normal conditions entered the sources of supply. It is probable that some of the very first works undertaken in this country of this nature were those which I had the honor of starting.

In 1874 I became much impressed with the dangers which
2237 threatened the purity of the water entering Lake Cochituate. Pegan Brook, one of the feeders of the lake, ran through the center of the town of Natick and was receiving yearly more and more contaminating matter. In 1875 I called the attention of the Cochituate Water Board to the necessity of adopting a vigorous policy to protect the purity of the water entering the lake. It was very difficult to secure any action, owing to the fact that there were no adequate laws existing at that time, under which prosecutions could be begun. In 1879 I made a detailed report to the water board showing all cases of contamination which existed upon the City of Boston's water supplies, and, under my supervision, a test case, Martin vs. Gleason, was begun. Augustus P. Martin was at that time Mayor of the City of Boston and Luther Ellis Gleason was at that time the manager of a hotel in Natick. The case was many years in court and the City of Boston was defeated in some of the lower courts, but finally won in the Supreme Court, and from that time began a system of protection and purification which has been continued ever since. Some of the brooks entering the sources of supply had in the meantime become veritable sewers, due largely to the fact that public water supplies had been introduced, and the water disposal system adopted in the smaller towns.

In 1885 a favorable decision having been made by the court, I was enabled to take hold in earnest of the preparation of plans to

remove all the sewage from the sources of supply. The general course followed was to pump the sewage, in the case of Natick and Framingham, on to filter beds from which the effluent was discharged into water-courses outside of the drainage areas. In the case of the city of Marlborough, after the sewage had been removed to filter beds, I found that the brook was still at times largely polluted and I designed and erected, under the general direc-
2238 tion of the City of Boston, a series of filter-beds near the banks of one of the largest reservoirs, so that the water of the brook could be filtered on these beds. The same policy was followed out, under my direction, in the case of Pegan Brook.

In addition to the works that I have described, I have in the course of my professional experience, been called upon to plan and advise cities and towns in connection with their sewerage works. I was one of the members of the commission which designed the sewerage system for the city of Cleveland, Ohio, and later made a report to the Philippine commission upon the system of sewerage works for the city of Manila.

In 1899 I was selected by a special commission appointed by the Governor of Illinois to report upon the Chicago drainage canal and in 1900 my report of 131 pages was printed.

I have recently designed a system of sewerage for the town of Manchester, Mass., and the report has been printed.

Q. Now, Mr. Fitz Gerald, coming to the immediate matter that is before us. What opportunities have you had for examination of the waters of New York Harbor and the Passaic River waters?

A. I have had, I think, good opportunities to examine them in detail.

Q. State some of your tours of inspection?

A. On July 5, 1911, I took a small steamer named "Raymond" at 11:30 A. M. The tide was coming in. Examined first the water around the Battery and noticed there drift-wood and sewage matter floating about in the small basins around the wharves. As we passed up the East River and neared the Brooklyn Bridge, I noticed around Pier No. 26 that there was a considerable field of sewage extending about 400 feet into the channel and that the boundary line of this sewage field was easily distinguished from the rest of the water. It was characterized by a strong saffron color. The edges were pronounced and around these edges floated pieces of paper,
matches, faces, orange peel, lemons, etc. At this point,
2239 I saw another mass of sewage water. In this vicinity is a tuberculosis hospital and quite close at hand a bathing establishment.

As we passed over to the Brooklyn shore, I noticed that the whole of the water in this vicinity was discolored by sewage discharges. We entered the canal connected with the Wallabout Basin but did not go very far into the canal.

About five minutes later the lines of another sewage field became more distinct. It extended 300 feet beyond the pier-head.

Q. In the vicinity of where?

A. In that same vicinity of the bridge.

Q. Now, keeping still on the New York side near Staunton Street in that vicinity?

A. The water became very dirty here and one minute was yellow with feces, large quantities appearing all through the water. Here we passed through another mass of sewage water and I saw boys bathing within 150 feet of it, and three minutes later we ran into another similar place near the Recreation Pier and the New York Yacht Club anchorage. Here I noticed boys bathing all along the shore and eight minutes later we saw some very offensive sewage, probably coming from slaughterhouses in this vicinity, which was of a strong reddish hue.

Q. Following up the East River?

A. More reddish water. At the Consumers Brewing Company the shore was well soaked with sewage discharges.

Q. In the vicinity of what street?

A. East 42nd Street is the point from my notes. I noticed boys bathing all along this part of the shore. At 59th Street we came to the Rockefeller Institute. Here I saw a large sewer discharging above the surface of the water. To the right lies Ward's Island. People bathing here at East 100th Street. Two minutes later we passed into the Harlem River and large amounts of sewage
2240 appeared on the left hand side of the boat. The city institutions were on the right. A little later, City Park and Recreation Pier on the left. Here I noticed a mass of milky sewage on the left all the way along. It was full of oil and feces and it extended from shore to shore. We noticed bad odors arising from this water. We turned around at this point and at five minutes past one reached the mouth of the Harlem River. At 1.35 we started again and soon passed Fort Morris on the left. I noticed a large sewer on the north but there was not very much matter discharging from it. Rikers Island lay on our right and the country at this point was getting decidedly more open. The bays on each side contained very shallow water and, although they cover large expanses the channel itself is comparatively narrow.

At Hunts Point I saw a large double sewer and in the vicinity a quantity of sleek. This is particularly noticeable where there is but little wind to ruffle the surface. We then passed the Bronx river and soon came to Clausson's Point.

Clausson's Point. This point was covered with tents and it was probable that there were twenty thousand persons either in camp or houses seeking recreation at this favorite spot. I saw a great many people bathing here.

Westchester Creek. When we arrived at this point, I noticed that the water had decidedly improved in appearance. It looked bluer and cleaner.

Throggs Neck. This neck is quite near to Long Island Sound and may be said to be the upper part of the East River. After going a little way into the Sound, we turned around and started on our journey for New York.

College Point. I saw dirty water on the left hand side of the boat. We passed to the southerly side of Rikers Island and were soon sail-

ing through a field of sewage water which had probably come
2241 from the neighborhood of College Point Ferry, one third of a mile away.

Bowery Bay, North Beach: Remarkable Coney Island development here on the left. This is evidently a favorite point for large crowds of people seeking recreation in the hot weather.

Hell Gate. I saw a large sewer, perhaps twelve feet in diameter, which evidently comes from Queens on the left. It had an excellent bulkhead.

Newton Creek. At 3.55 we arrived at this point and I noticed many boys bathing here not far from the drawbridge.

Q. On any other days did you make any tour of inspection?

A. Yes. On July 6th, 1911, I took a smaller boat named the "Quadrant." The wind was from behind. We passed rapidly over the former ground examined but I could see masses of sewage water of saffron yellow contrasting strongly with the general bluish tint elsewhere. I was much struck with two points in connection with there fields of sewage discharge. The first was that diffusion proceeded slowly and was unsatisfactory; and second; that the paper and sludge both had a tendency to settle in the water. Much foecal matter was observed as we passed along. We sailed through the 14th Street sewage field and the color of the water gradually became grayish black as we advanced. The wind was carrying it ahead of the boat. I took this to be an effect of more advanced decomposition, in other words that the sewage had become more septic. At 11:20, we arrived at East 100th Street off Randalls and Wards Islands, having passed through a large field of sewage discharged from the East 10th Street sewer.

In the Harlem River there was a bad smell in the air. Wind still behind us. The current southerly and the tide near low water. At 11:30 I noticed the Bourke Avenue sewer at its outlet. There was a bulkhead on the right. It extends up the Bronx under the first bridge. A few minutes later, at 11:32 we arrived at the Third
2242 Avenue elevated bridge. The water is here practically all of the same quality and from the surface to the bottom very bad. The passing boats keep it stirred up. I noticed a sewer entering the stream on the right under the bridge. It was of egg shape. At 11:33, at the fourth bridge, there was a very foul mass of sewage. At 11:35, we arrived at Madison Avenue, the 5th bridge. A minute later, as we went up the Harlem River, I saw children at the mouth of the sewer wading on the left of the boat. At 11:37, we arrived at 149th Street bridge and here there was a mass of paper and foecal matter all along the river. I saw another large sewer on the left and we passed a mooring-place connected with rowing clubs. It seemed to be too bad that they should be obliged to row in such filthy water. It was very foul and extended across the stream. It was gray in color.

11:41 Central Bridge: Here the boys were bathing in water of such bad quality that it gave out a bad odor.

11:43—155th Street Bridge. The speedway is on our left and on the right a railroad yard. Just ahead of us we see the old Croton Aqueduct bridge, with the arches of steel beyond. I noticed on the

left, under the speedway, a sewer, at 11:46 and at 11:48 we arrived at Highbridge.

Highbridge.—A short distance farther up the stream was the Webster Avenue relief sewer composed of two large arches, on the right the water was of a very bad gray color.

Washington Bridge. Here I noticed that the water was effervescing in every direction and that it was full of human excrement. We passed near to the right shore where there were some boat building establishments.

Q. In the neighborhood of what bridge, are you now discussing?

A. Washington Bridge. At the 207th Street bridge that water contained orange peel, lemons, faeces and a yellowish scum. There is a railroad on the right. The banks are now rocky. We are
2243 in the ship canal. I notice people getting out oysters and clams as we pass not far from an iron foundry.

Hudson River, 12:10. At this point we ran into a head wind and the water was all stirred up. The Bronx Valley sewer empties above this point. I believe it takes the sewage of White Plains, Tuckahoe, Bronxdale, Scarsdale, etc.

Fort Washington Point. Here we saw men taking shell fish out of the Hudson River and at 12:30, we arrived at the Washington Heights Park, 155th Street where I saw 100 people bathing. We have now on our left, Riverdale Park, all the way along, the same at 149th Street.

79th Street—12:50—Here we came across a solid field of sewage water 350 feet beyond the shore. Here there is a bathing establishment and children are bathing in the sewage water. As this institution is maintained by the city, I got out of the boat and walked about and noticed how very bad the water was. It was effervescing and contained faeces, paper, bottles, lemons, orange peel, grease, matches and sewage. In color it was grayish and it was very foul. A little later, at 72nd Street, I noticed more of these effects. At 66th Street, we came to Hell's Kitchen where I saw more sewage water. At 50th Street was the Recreation Pier and sewer. I noticed similar effects due to sewerage discharge at 43rd Street and at the Panama Railroad wharf.

Q. Did you make any tour, conduct any tour of inspection of Jamaica Bay, the Upper and Lower Bays?

A. Yes.

Q. When?

A. On July 7th.

Q. State what your observations consisted of on July 7th on this tour of inspection?

A. On July 7th, 1911, we took the steamer "Ed Moran" 10:50—In starting in the morning we had a strong head wind and we passed down towards Governors Island, leaving that island on the right. In fact we were in Buttermilk Channel. I noticed that the water was covered with oil within a point 200 feet from the
2243½ wharves. We were not far from the outlet of the Gowanus Tunnel. By means of this tunnel, the very offensive water in Gowanus canal is pumped directly into Buttermilk Channel. The condition of the water at this point is very offensive. It is black. I

noticed that the passing boats stirred it up and it appeared to be full of manufacturing refuse. A sewer was discharging gray matter into the channel, but we had at times as many as three distinct shades of coloring, yellow, black and red. We followed this sewage field in a southerly direction. It was quite easy to do so on account of the oil and black putrefying material. It seemed to hold together on a line about 250 feet outside of the docks all along. We passed near to the Atlantic Basin and I noticed that the sewage extends from one half mile to a mile.

Q. That is the sewage field?

A. Yes. A little later, South Brooklyn appeared just ahead of us and the water began to grow better, but at 11:20, on arriving near Gowanus canal, the water was quite dirty. The canal itself was so blocked by barges that we could not get in and had to back out. At this time, we went to the shore and took on a pilot. The Brooklyn sewers discharge near the bulkheads. At the Bush Terminal and Norton & Son, there was a great mass of sewage and at 11:55, we passed through a field of sewage from which emanated bad odors.

11.56 Bathing Beach. I noticed a triple outlet sewer, but not much discharge from it. Here is City Park, Bay-Ridge Parkway. It seems to me that now the population was growing decidedly less and the country more open. We passed large sewers all along the shore and I was assured by some one on the boat, that Mayor Low at one time rode an automobile through one of these sewers. Nasty water all along. The houses, however, are becoming finer. More country places.

2244 Narrows on the right. We passed along through Gravesend Bay from which the sewage has been removed and carried to a point above the Narrows. The pleasure resorts however, are of rather a cheap nature. We passed the Brooklyn Yacht Club and at 12:30 arrived at Coney Island Channel.

Norton Point. I noticed a number of dredges working in the different channels including the celebrated Ambrose Channel. We passed over to Rockaway Beach examining the water all along and finally entered the narrow and difficult channel which gives access to the bay. The great garbage works are on the left. There is a great extent of beaches in this direction and houses of more or less importance, but a great many people are living in tents. They come here to escape the heat of the city.

Jamaica Bay. We arrived near a drawbridge in the railroad which passes across Jamaica Bay cutting it into two parts. On the outside was a narrow strip of land very thickly populated. We returned to the Battery. Those are the principal matters I noticed on that day.

Q. And you finally returned to the Battery?

A. Yes, we finally returned to the Battery.

Q. On any other day did you make a tour of inspection of our harbor waters?

A. I did.

Q. What day, sir?

A. On July 24th.

Q. What year, sir?

A. 1911.

Q. State what your inspection consisted of on that day and what your observations were?

A. On July 24th, 1911, at 10:42—Hudson River front—Dr. Parsons and I left the float at the Battery. The tide is running flood and it is near the end of the tide.

Q. Were you accompanied by any one?

A. Yes, Dr. Parsons was with me that day.

Q. Who is Dr. Parsons?

A. He is the oxygen expert, I should say, connected with
2245 the Metropolitan Sewerage Commission of New York. I noticed much turbidity in the water.

Q. At what point was that?

A. That was when we first started out, a short distance out from the Battery. I took a sample outside the slip and noted a greasy scum on the surface of the water, although moderately clean otherwise. It contained fine particles, but was much better than in the slip. Off the Lehigh Valley, Pier No. 3, the wind was blowing spray and water into my mouth and I could see how trouble might easily ensue from this state of affairs. In other words, dangerous germs might very easily be blown directly from the water on to the person and even into the mouths of those sailing on the bay.

Q. Did you go into any of the slips?

A. Yes, many of them. At 10:52, we passed into one of the slips, selected at hazard, and I noticed oily scum on the surface, 75 feet from the head of the slip. Three minutes later, we arrived at the bulkhead line or head of the slip, but there was no diminution in the thick greasy stuff. Near the pier head there was a mass of garbage which was not so bad. 250 feet off the head of the pier, however is a strong wind, there was still a thick, greasy scum, which seemed to be prevalent everywhere.

Pennsylvania Railroad, Pier No. 5. At the head of this Pier, I still found a greasy scum in the channel and the same state of things in the next pier below, but the water here was full of bubbles of gas, showing a strong effervescence and septic decomposition. 400 feet out in the harbor there was still a greasy scum.

Central Railroad of New Jersey. Even in this strong wind the line was well defined between the sewage field and the other waters. Fifty feet from the sewer I took a sample and found it full of foeces; and 300 feet out into the harbor there was still a greasy scum.

Liberty Street. Here I took a sample 300 feet from the pier
head and found scum on the surface. I also saw a few small
2246 pieces of foeces. There seems to be no uniformity in the places from which the sewage is discharged. At one place it would appear one color and at another, another color.

At Pier 13, 11:25, the water was full of foeces and foul smells. We were at the foot of Fulton Street, and the water contained gas bubbles, and also full of minute particles of greasy material. A second sample was full of foeces. At the head of the pier, the water was so black that I could not see the bottom of the pail in which I

took the sample, but 300 feet out from the pierhead, there was nothing but a greasy scum visible.

Near the Providence Line the water was nasty at this point. On the left there is a sewer discharging here and the water half way up the dock is full of foeces. I took two samples. Erie Pier 20. The water was turbid. Around the foot of the pier was a large field of sewage. 300 feet out was the persistent scum that I had noticed everywhere on the Hudson River where we took samples.

On this trip, I took no chart purposely in order that I might not be influenced by the conscious knowledge of the presence of sewers; in fact, we did not know where the sewers were located but took the samples at random. I wished to form a clear idea of the condition of the water irrespective of its position.

Near the People's Line there was oily scum 300 feet out from the pier.

Q. What pier would that be in number?

A. Pier 32 I think. At the head of the dock I found orange peels, foeces and that the water was blackened while the scum was very thick. Here are sewage discharges, corks, paper and foeces. At this moment, the sun came out and matters appeared much worse. They seem to be very bad around the Clyde Line, Pier 37, and the Mallory Line.

Lackawanna Pier 41. Here we found dirty water and a
2247 little later, at Pier 43, 300 feet off in the Hudson River the usual scum. This is a Reservation Pier and the Catskill Evening Lines are situated at this point. At Pier 44, the dock was so full of boats that we could not go in, so we took a sample of the water at the foot. It contained scum. At Pier 46, there was dirty water and we passed naked boys in a boat.

Duane Street, Pier 50, Western Electric Company, Oyster Market, Piers 52 and 53. At this point, there were plenty of boys in swimming. At Pier 61, The Red Star Line the water was dirty.

Pier No. 65, 12:15. This is at 26th street. "Atlas" The water is full of sewage and has a very bad smell. The whole slip was full of sewage, the samples disclosing forces, grease, and everything else characteristic of sewage. It was here that I saw jet black masses of erupting gases. This was certainly worth seeing. 300 feet out from the end of the pier the water contained this black scum. As we passed along I noticed a few bathers at Pier No. 76 also a mass of sewage. There is a sewer discharging here out at the foot of the pier and there are bathers. At 43rd street at the Hudson River Day line, there is an oily scum. The water looks better but bubbles are rising through it. At 12:30, we haul up, turn around and return to the Battery. Left again at 2:30 and on the way up the Hudson River I found many swimmers. At 3 o'clock, we arrive at Pier No. 71 owned by the New York Central. There is a sleek like straight across from the middle of the dock and a very bad sewage field. The water is of a dull grayish color, contains bubbles and a very bad smell stirs up as our boat turns. 250 feet outside of the dock is the usual oily scum.

We then pass down the Hudson and notice several fields of sewage

in the docks, at 3:23, we arrived at the Recreation Pier and see a sewer discharging under the pier. I collected a sample and
2248 found the usual characteristics. 250 feet outside of the pier, was the usual scum, etc. There is a cable crossing south of this slip. By hazard, the Captain selected a dock which was easy to get into. It was, I think, consolidated Gas, No. 46. At 300 feet from the end, a sample showed grease, etc., but we did not see any sewer discharging there. Boys were swimming in the water and 200 feet outside of the dock was the usual grease on the surface. Just outside of West 43 Street where the New York Central has its freight line, was a bad sewage field continuing beyond the end of the pier; and off 40th Street, in the slips, was another bad sewage field, and at 25th Street and 36th Street another. We then returned along the front and at 3:50 ran up into a slip by the side of the oyster docks, where I saw much bathing but did not see any sewer. This is Gamford Street. The water was covered with scum.

Q. Now, Mr. FitzGerald, at any time did you make a tour of inspection of the Passaic River or the Passaic Valley?

A. Yes.

Q. When?

A. On September 6th, 1911.

Q. Who accompanied you?

A. Harrison P. Eddy, Dr. Edward Ellery, John W. Alvord, Robert Spur Western and Herbert Pease.

Q. State when you started on that day?

Mr. Riker: I object to it on the ground that it is immaterial and irrelevant. It is not evidence in this case material to the issue to know what the conditions were in the Passaic River.

The Commissioner: Note the objection of Counsel for Defendants.

Q. Proceed, Mr. Fitz Gerald?

A. On September 6th, 1911, Messrs. Eddy, Ellery, Pease, Western, Alvord and I took the 9 o'clock A. M. train from the Pennsylvania Station at 33rd Street for Newark. On arriving in that city, we hired an automobile and went to the city engineer's office to secure some information. We then rode in an easterly direction to New-
2249 ark Bay and arrived at the site of the proposed pumping station of the proposed Passaic Valley trunk sewer system on the Meadows, south of Doremus Avenue.

Q. Who indicated the location to you of the pumping station?

A. I ascertained that myself.

Q. From the City Engineer in Newark?

A. I do not recall precisely, but I think from a map, also by consulting with the engineers, but we had some difficulty in finding it.

Q. You may proceed, Mr. Fitz Gerald?

A. Before starting on this expedition, we bought a pail, dipper and cord with which to take samples wherever we went. I noticed that in spots the water in Newark Bay, quite near the shore, was dirty, but a short distance out it did not seem to be so bad. We examined as well as we could in so short a trip, the great extent of the Meadows and discussed the possibilities of building purification

works. At 11:05 we arrived at the 4th Street bridge on Jackson Street and found the water very foul. The tide was running out, but the recent rains have helped the appearance of the water somewhat. It was however very full of oil and the smells were bad. At 11:20 we arrived at the Clay Street Bridge, farther up stream. The water here is black and foul. Wind south by west. Bad smell. On the westerly side of the bridge I noticed a large amount of fresh sewage entering the stream, which otherwise is in a septic condition. On the easterly side I could also see sewage matter. The stream is about 300 feet wide and this is East Newark.

11:40.—We followed up the bank of the river on the northerly side and at 11:40 arrived at a point opposite some paint works. The water is full of a greasy scum and is foul. The sewers enter on the opposite shore. The tide is ebb. There is floating scum.

Crull's Boathouse.—I noticed that the white paint of the boats was very dirty and in some places black.

12 M. in Arlington.—Here there is a railroad crossing high above the river called the Belleville and Arlington Bridge. At
2250 12:04 another sample contains grease and other stuff, floating on the surface. On the right, we pass the works of the Old Jersey City Water Works. I notice septic bubbles in the water arising from the bottom, showing the foul condition of the bottom.

Q. Bubbles of what?

A. Of gases.

Q. Putrescent gases?

A. Yes, putrescent gases. At 12:20 crossed the river from the West to the East bank. We are in Avondale. Then we passed into Delamara and at 12:40 arrived at a point below the railroad bridge. The water at this point is black, opaque and not quite so yellow as before. I collected the sample myself. I remember going down a slippery bank to get it.

At 2:10, we went to the river by way of Monroe Street, crossing a canal. Contained turbid water and much suspended matter. We went into a drug store to purchase some bottles. At 2:25, we reached the river where there was not much water but the current was swift. We passed up on the westerly side of the river and in a few minutes passed a large factory on the left discharging blue manufacturing waste into the river. The water, however seems to have less material in suspension. It is disagreeable, vegetable and has a color of about 28.

Falls, 2:40.—Rather pretty. About 16 feet high and 500 feet across. We sampled the water, as we have done everywhere from the start. At 2:45, we passed through Paterson and noticed much greasy scum on the surface, oil and smell. Dead water. At 3:07 we arrive at a deck bridge. It is of three arches, of concrete, and then six spans of iron and then passed under one railroad and over another. At 3:28 we arrive at Main Street Bridge, Paterson where a sample showed the water to be much clearer, but it contains vegetable matter floating on the surface. The dyehouses and all the manufacturies as far as I could see or learn empty into the river.

Q. Did you visit Great Falls?

A. We did. At 4:40 we visit Great Falls. Here the water
2251 is very much better than anything we have seen, but it has a strong vegetable odor.

Q. Mr. Fitz Gerald, on any other special day, did you make a tour of inspection or our harbor waters taking in the East and Harlem Rivers?

A. Yes.

Q. Did any one accompany you on that tour?

A. Yes. Harrison P. Eddy, Robert Spur Western, Professor Edward Ellery, Dr. George A. Soper, Professor Floyd J. Metzger, Professor William P. Mason, Professor Earle B. Phelps. This was on October 19th.

Q. What year?

A. 1911.

Q. State where you went and what you observed, Mr. Fitz Gerald?

A. On October 19th, 1911, Messrs. Eddy, Weston, Ellery, Soper, Metzger, Mason, Phelps, and I left New York on a large tug for an examination of *that* East River, the Harlem, etc. We went up to Throgs Neck and then passed up the Harlem, lunched at 145th Street, and I left the boat at 92nd Street. It was on this trip that I saw the phenomenon of a large mass of yellow water extending from the shore to Rikers Island with a large field of sewage in it, as we passed down the East River towards Harlem on our way from Throgs Neck. I think that sewage field that I saw on that occasion was one of the most interesting ones that I have ever seen anywhere.

Q. You are now alluding to the one in the neighborhood of Rikers Island?

A. Yes. It extended from the shore over within a distance I should think of three quarters of a mile, and it was characterized by the usual material that you see floating around the edges of the sewage field, such as pieces of cork, orange peel and so forth, feces.

Q. Mr. Fitz Gerald, did you give any study to the Passaic Valley Trunk sewer project?

A. Yes.

Q. And the reports of the Passaic Valley Sewerage Commissioners?

A. Yes, I did.

Q. What report of that commission did you take into consideration?

2252 A. The report made in 1908. That was entitled "Report of the Passaic Valley Sewerage Commissioners to the Municipalities lying in whole or in part within the Passaic Valley Sewerage District, 1908."

Q. State what studies you have given to that project?

Mr. Riker: I object to the question on the ground that before evidence as to studies of this report is competent, the report itself must be proved in the cause.

The Commissioner: Note the objection of Counsel for Defendants.

Q. Proceed, Mr. Fitz Gerald.

A. In 1903 Commissioners made a report to Legislature recommending building of a main trunk or intercepting sewer along the west bank of the Passaic River from the Great Falls at Paterson to a pumping station on the Newark meadows, the sewage thence to be pumped through steel force mains under Newark Bay into a main sewer across Bayonne neck to an outfall in New York Bay near Robbins Reef light. From a study of this report I found that further study that these commissioners made only confirmed the previous investigations, and that the general plan was unchanged, but there were certain changes made in alignment of the main or intercepting sewer, reducing the length and it is now proposed to use concrete for the entire length above Newark Bay. I am quoting from the report itself: "From Newark bay to outfall, however, it has been deemed advisable to recommend a different construction from the one proposed in the former plan, which did not provide outfall facilities for the full capacity of the main sewer. Recent developments in tunnel construction and the opinion of eminent engineers have led the commissioners to recommend the plan of conveying the sewage from the pumping station at Newark Bay, through a deep tunnel direct to the outfall in the New York Bay. This plan, while it will not materially increase the first cost of the plant over that previously advised, will make available the full capacity of the main sewer at once."

2253 Q. You have quoted from the report?

A. That is the end of the quotation. The proposed district sewer was by this report located close to the west bank of the Passaic river with the exception of a short stretch in Passaic and above where the river bends. Before determining sizes, the Commissioners ascertained the present population of the various municipalities lying within the sewerage district and also within the entire natural drainage area between the falls at Paterson and Newark Bay and the rate of increase of the population. I have here a table as follows:

The total cost, including property by rights, is.....	$12,250,000
The cost of maintenance for 120,000,000 gallons per day is	170,000
Per annum, increasing gradually to.....	283,000
for full capacity of 360,000,000 gallons daily.	

Upon basis of $12,250,000 cost and bonds at 4% and sinking fund of 1% to retire them at maturity, the annual cost will be $612,500 per annum.

To be completed in 4 years.

Tax rate, 90 9/10 cts. per $1,000 on bonds, &c., but not including maintenance.

25 4/10c. per 1,000 for maintenance, differently apportioned.

The report describes the capacity as made up of "Sewage and other polluting matter.

Essex county.

City of Newark
City of Orange
City of East Orange
Town of Bloomfield
Bo. of Glen Ridge
Town of Montclair
Township of Belleville
Town of Nutley.

Passaic county.

City of Paterson
City of Passaic
Township of Acquackanonk

Bergen county.

Borough of Garfield
" " Wallingford
" " E. Rutherford
" " Rutherford
Township " Union
Borough of N. Arlington.

Hudson county.

Town of Kearney
" " Harrison
Borough of E. Newark.

Q. Where did you get those facts that you have just read?
A. From the report.
Q. Did you take into consideration the engineer's report?
A. I did.
2254 Q. In your studies of the Passaic Valley sewerage project?
A. Yes.
Q. State what facts you took into consideration from the engineer's report?

Mr. Riker: The question is objected to on the ground that things in the engineer's report are not competent in any case in this suit, and they could only be used for the purposes of evidence after it had been proved in the case.

The Commissioner: Note the objection of Counsel for Defendants.

A. I found from the engineer's report that to the north and east of Paterson and between it and Garfield, there is an area tributary directly to the Passaic Valley of 10.8 square miles. This area includes a portion of Prospect Park not included in the drainage area of Oldham Brook, Gaffle Brook, and portions of Hawthorne, Ridgewood, Glen Rock and Saddle River township.

Mr. Riker: I move to strike this testimony out as being hearsay, and any further testimony of this witness which is simply repeated from the report of the engineers.

The Commissioner: Note the motion and objection of Counsel for Defendants.

Q. Proceed, Mr. Fitz Gerald?
A. I procured a table of data from this same report.
Q. One moment. After enumerating those places in the drainage area, would those places that you have just enumerated, naturally drain into the Passaic River?

Mr. Riker: Are you speaking now of his own knowledge; what places do you refer to, may I ask.

Mr. O'Sullivan: The ones he has just enumerated Oldham Brook, Gaffle Brook and portions of Hawthorne, Ridgewood, Glen Rock and Saddle river township.

The Witness: Well, I am not able to state that exactly. I presume that they do, but I cannot remember whether all of them do wholly or not.

2255 Q. Mr. FitzGerald, what other data did you take into consideration in your study of this Passaic Valley Sewerage project.

A. I took into consideration the data in regard to the computation for the different sizes of this sewer, and I found that it is based on the population, the area, and that the trade waste had been carefully studied. This is shown in the following table:

Table of Data.

Municipalities	30	
Population 1900	519,043	
" 1905	601,817	
" 1940	1,649,440	
Yearly increase 1900-1905	3.1%	
Total area tributary, including addition	103.23	sq. miles
Estimated Population 1905	587,457	
" " 1911	702,400	

Area 61,827 acres taking out meadows.
Population per acre, 9.5 in 1905.

To design sewer, the following data were taken:

Population	1,649,440	
Area	61,827	acres.
Population per acre	27.1	

Capacity of sewer Maximum flow, sewage trade wastes and leakage.
Trade wastes were carefully studied and maximum flow 62,482,000 gallons total daily flow taken.
Ground water was 47,400,000 m. g. daily total flow.
Grand total—357,365,200 gals. 24 hours.
Value of n=.015.
Maximum flow ¾ full.

Mr. Riker: The same objection as to the previous testimony on the engineer's report.

The Commissioners: Note the objection of Counsel for Defendants.

2256 Q. Proceed, Mr. FitzGerald?

A. "For the present the district sewer will be larger than necessary for the sewage and subsoil water of the entire district, as it

it proportioned for the needs of the future. It is possible therefore to make use of the extra size by admitting a more dilute sewage from the combined sewage of Paterson, Newark and elsewhere than can later be admitted."

"Until those cities change from the combined to the separate system and admit only sewage to the district sewer, it will be necessary to make connection with the present combined sewers and arrange overflow, so that during rain storms the excess of storm water beyond that quantity for which the district sewer is designed, can flow directly into the Passaic river." Sewage delivered to pumping station 26 feet below high water. I was interested in the description of the sewer. Beginning in Paterson at Prospect Street, a short distance below the great falls, sewage above this point will be brought by local sewers. Here it is 4 feet — diameter and will accom-odate not only the sewage from Paterson above the falls, but also the territory in the natural drainage area above Paterson, shown on plate A.

Q. In the report?

A. In the report. The sewer then follows the west side of the river, and near the river bank, except in big bend at Passaic, increasing to 13½ feet at Newark = max. diameter. Venturi metres, tunnels, siphons and small pumping stations are accessories.

In Passaic it is 9 feet — diameter, &c.

Near Clark Street in Newark—12½ feet — diameter.

Sewage on east side of river was to be brought by siphons—silt chambers.

Silt catchers, regulators and overflows.

Mr. Riker: The same objection.

The Commissioner: Note the objection of Counsel for Defendants.

2257 *A.* "The regulators automatically close during a rain storm after the main sewer has been filled to a certain height with the first washings of the local sewers and allow the balance of the water (practically rain water) to pass through the overflow to the river."

Since the above report was made an agreement has been entered into between New Jersey and the War Department by which it is planned to build settling basins on the Newark Meadows at the pumping station. These basins are to be of a capacity to retain one hour's flow. The details of these works are shown by photographs but no plans are accessible.

By the detention of the sewage for one hour in these basins a certain proportion of the matter in suspension will be removed.

Q. Mr. Fitz Gerald, have you had shown you the 135 exhibits on behalf of the Complainants in this suit?

A. Yes.

Q. And did you examine them?

A. I did.

Q. Have you read the hypothetical question which I put to Mr. Eddy yesterday?

A. I have.

Q. Now, assuming the facts as therein set forth in that hypothetical question, what would your answer be to that question.

Mr. Riker: The question is objected to on the ground that the hypothesis does not enumerate the facts upon the assumption of which the witness is asked to testify, and that the facts are not presented in such form that the court may determine whether or not they are substantiated by the evidence. The hypothetical question is defective and the answer will be immaterial and irrelevant.

The Commission: Note the objection of Counsel for Defendants.

A. My opinion is that if New Jersey is allowed to construct this tunnel and discharge the sewage as set forth in that question that the result will be extremely dangerous to the interests of the
2258 harbor waters, and other interests connected with the vital interest of New York.

Q. What reasons have you for that opinion, and on what observations and knowledge on your part does that opinion rest?

A. There are many reasons. Among them, because the putrescent condition of the waters of the harbor in the Upper Bay are bad, the present condition is bad. The present condition of the waters of the harbor in the Upper Bay is bad.

Q. What waters do you mean, describe the waters in the areas?

A. I mean all the waters surrounding New York. The waters comprised in this particular consideration have the following areas:

Upper Bay	21.00	square	miles	
Hudson River to Mt. St. Vincent	14.50	"	"	
East River	14.50	"	"	Round
Newark Bay	8.35	"	"	numbers
Arthur Kill	5.00	"	"	but very
Kill van Kull	1.15	"	"	nearly
Harlem River	.50	"	"	correct.
	65.00	"	"	

Q. Did you take into consideration the population of the Metropolitan Sewerage District?

A. I did. The population of the Metropolitan Sewerage District may be taken as follows, according to the best authorities:

1890	3,295,534
1900	4,565,477
1910	6,424,530
1940	12,846,560

Q. Do all of these then drain into the above waters?

A. I presume not all of them, but the great mass of them. But the figures are nearly enough correct to give a fair idea, and they indicate in an alarming manner the increased growth of this great center of population and the vast accumulation of filth which will

enter the harbor waters in a very few years if some wise and
2259 serious steps are not taken at once to provide a remedy. Much has been written on the subject matter and many investigations have already been made. The most important of all is the Report of the Metropolitan Sewerage Commission, published in 1910, together with some of its supplemental reports which have also been published by this commission in connection with that report. I may say that the series of dissolved oxygen investigations made by that Commission is perhaps the finest that has ever been made, at least upon this side of the water, and enable us to form an idea of the condition of the waters surrounding New York.

Mr. Riker: Is this evidence, Doctor?

Mr. O'Sullivan: I am asking him for his reasons now.

A. They enable us to form an idea of the condition of the waters surrounding New York. I have studied carefully a large part of the work of this Commission and have acted upon Committees of experts to collate and sift evidence.

Q. How long have you been doing work on the work of the Metropolitan Sewerage Commission?

A. I cannot recall exactly. I should think likely nearly two years. Not for the Metropolitan Sewerage Commission but on this case and on the Metropolitan Sewerage Commission.

Q. Both?

A. Both, yes. In addition to this, I have examined a large part of these waters personally, have taken samples and have followed in a boat a great many of the so-called sewage fields and have been a personal witness to the very bad condition of the waters of the harbor—especially about the docks of the East and Harlem Rivers, the Brooklyn shores, Buttermilk channel, Newark Bay, the Passaic river and the waters of the Upper Bay and Hudson River.

In very many places the water is today intolerably filthy—so much so as to alarm a careful observer and cause concern as to what the outcome is to be. I have seen large fields of sewage and
2260 manufacturers' waste and followed them for long distances, in one case at least for more than a mile. Harlem River is evidently at times a little better than an open drain and foul and effervescing sewage discharges stretch from shore to shore. One of the striking features in connection with these sewer infected waters is to see the large number of bathers in the hot season who swim and bathe in close contact with sewer discharges. In some cases I have seen them bathing in the areas of "sleek" and well defined sewage fields.

The following is a brief outline of what I have seen many times and will give a fair idea of what a sewage field is and of its conditions at different stages of its progress and of the persistence with which it hangs together before its final assimilation by the surrounding waters under the influence of the tides and winds.

In the case of a sewer discharging at the bulkhead line, the sewage gathers in a mass in the slip. At the head of the slip where a large part of the solids sink, a disgusting condition of decay is in progress.

Bubbles are constantly rising through the water and break at the surface, a sure index of putrefaction going on below. In some cases I have seen large pieces of black matter brought up with considerable velocity from the bottom turning over at the surface; a bad odor fills the air.

Farther down the slip a diagonal line indicates the course of the currents and, if the adjoining piers are open, the mass of the field which is forming passes into the adjoining slip—and eventually finds its way outside the pier lines. It can at all times be distinguished by the appearance of the "sleek." The sewage is now principally confined to the surface. In quiet water, the boundaries are clearly defined and, owing to the presence of a large amount of grease, in rougher water, it may still be distinguished on account of the glassy appearance.

In the fresher "fields" the color is usually a decided yel-
2261 lowish or saffron tint. As the sewage becomes older, it changes to a dull grayish color and may finally become almost black. If we approach the edges, we find that the boundaries are often clearly defined, the difference in the character of the "field" and the rest of the harbor water being well marked. We find many substances here which decay or break up slowly—corks, paper, matches, lemon and orange peel, fæces, pieces of greasy scum, etc. The mixing with the surrounding water goes on slowly. Finally, after long distance, nothing but a thin greasy scum remains and this is visible at all times well outside the pier heads. If the weather is stormy, a sample taken in a pail will show the presence of the scum. I have already referred here to the appearance of that sleek field or sewage field rather accompanied by sleek, which I noticed in October on a trip from Throgs Neck near Clasons Point. I do not think I will repeat it. The boat steamed through it for some distance. The front of the dirty or yellow water had a length of about two miles and the sewage about three quarters of a mile.

After personal examinations, I have become convinced that the Hudson river water along the whole city front is badly polluted; that the East River nearly to Clauson's Point is in a similar condition, that Harlem river is badly polluted, that the Brooklyn front is badly polluted. The effect on the Upper Bay is evident but more difficult to distinguish in its central portions by means of the senses alone. For a clear understanding of the effects of the large sewage discharges from the Metropolitan District in the mass of the Upper Bay waters, we must rely upon analyses.

Dissolved oxygen: In 1909 and 1911 a large number of dissolved oxygen determinations were made under the direction of the Metropolitan Sewerage Commission, Those observations covered nearly every portion of the harbor waters. In 1909 we have the results of 782 analyses available and in 1911, 1062 or 1844 in all. Those
observations were I am of the opinion carefully made by the
2262 best method known to science—viz: the Albert Levy method.

Water, fresh and salt, contains in a pure condition a certain amount of oxygen in solution; the amount depending upon temperature principally. The quantity of this oxygen gas absorbed has

been determined and tabulated. When decomposing organic matter is introduced into the water, the dissolved oxygen is used up, creating a lack of oxygen which thus becomes a measure of the extent of the decomposition and the capacity remaining in the water for further purification.

My confidence in the accuracy of these oxygen results is fortified by the fact that, after a rigid examination of the methods employed in the determinations of the dissolved oxygen by a large committee composed in large part of some of the best experts in the country, no flaws could be found in the work of the Metropolitan Sewerage Commission in this respect. I happen to have been a member of that committee.

Q. Did that committee in taking into consideration the oxygen work done by the Metropolitan Sewerage Commission, which is in evidence in this case as Complainants' Exhibits Nos. 31 and 94, subject them to experimentations to determine the reliability of the method?

A. Yes.

Q. And examine them in other respects?

A. Yes.

Q. And with what results?

Mr. Riker: I object to it as being immaterial and irrelevant.

The Commissioner: Note the objection of counsel for defendants.

A. The committee made a report of which the following is the conclusion.

Q. Are you a member of that committee?

A. I was.

Mr. Riker: I wish to note an objection to the reading into this record of conclusions of the commission which is not recog-
2263 nized in any way as authority on the the subject matter, and is at best mere hearsay, not subject to cross-examination.

The Commissioner: Note the objection of counsel for the defendants.

A. The conclusion is as folows: In conclusion, it may be stated that the Committee had, through its own investigations, assured itself that the modified Levy method of determining dissolved oxygen, as adopted by the Metropolitan Sewerage Commission, is more reliable than the Winkler method, and that the results obtained by the Metropolitan Sewage Commission, so far as they are dependant upon the method used, are reliable, and that any further determination which may be required should be made by this method.

Q. That is the conclusion?

A. Yes, that was an official question.

Q. Did you take into consideration any percentages taken from Complainants' Exhibits 31 and 94?

A. I did.

Q. If so, state what deductions you draw therefrom?

Mr. Riker: The question is objected to on the ground that this

witness has already testified to it in answer to the question involving these hypotheses.

The Commissioner: Note the objection of counsel for defendants.

A. The following percentages of dissolved oxygen found at important points are the results obtained from the average of many determinations.

Mt. St. Vincent—120 samples, both currents 72% showing that in times of Summer flow the Hudson River has been robbed of 28% of its complement of dissolved oxygen before it enters the limits of the City of New York.

At the outlet of the river, near the Battery, or Pier "A" the average of 210 observations at both currents, flood and ebb, gave 56%.

2264 Sections taken across the river in 1911 showed that at ebb tide the percentage occasionally gets below 50 and that all the way across, in the fifties, as a rule, at flood, in the summer, when the flow of the Hudson is small. In 1909, at midstream, July 22, 64%—68%, depending on the depth, flood tide; at ebb 57%—59%. July 26, 1909, 58% ebb.

These observations show that in 1909, near the Battery, the percentage got below 60% at ebb and below 70% at flood. (See p. 113 for a fine set of observations).

Upper Bay—75%.

1909. Ebb tide 64%—60% (Sheet 1)
" " 64%—65% (" 2)
" " 62%—69% (" 3)
Flood tide 72%—74%

1911. Average of 117 samples taken in the vicinity of Robbins Reef showed 73% average of both currents (not much difference) showing a condition of less than 75% in the summer season.

The Narrows.—80%.

1909. 37 samples 83% all depths and tides.
1911. 132 " 79% " " " "
showing about 80% in summer season.

Newark Bay, Lower End, 64%.

1909. 25 samples 76% all depths and tides.
1911. 66 " 64% " " " " Lower end of bay:
or somewhat better at the lower end than the Hudson at the Battery. In other words, Newark Bay is taking care of the Passaic Sewage in its crude state as well as the Hudson is doing at the mouth (near the Battery).

East River. 86%—55%.

1909. 39 samples above Hell Gate gave 86%
" 135 " below " " " 66%
1911. 54 " at Throgs Neck " 86%

2265

1911. 30 samples at Blossoms Pt. gave 67%
" 99 " " Lawrence " " 57%
" 180 " " Mouth " 55%

so that the influence of the East River upon the Upper Bay cannot be a purifying one as it is very close to a minimum standard of 50%, and adds to the load of decaying organic matter which the upper bay has to carry.

Q. What do you regard as the standard for dissolved oxygen?

A. It is a matter I presume that every man has to determine for himself, but it seems to me it is an important question.

When the dissolved oxygen present in the waters of the harbor is used up in the natural processes of decay, then the putrefying changes in the sewage must be arrested and it will accumulate in the harbor as in a large open cesspool. Such a condition of affairs will be practically intolerable and dangerous to health and to great commercial and other interests of the largest and most progressive port in the world.

In the summer season, when the water contains normally less dissolved oxygen than when the water is cold, the dissolved oxygen at the mouth of the Hudson River across from the Battery to the Jersey Coast is nearly half gone; that the same condition prevails in the outlet of the East River and that in the middle of the Upper Bay it is about one quarter gone, while around the margins of the Upper Bay the water is in many places badly polluted.

The amount of dissolved oxygen is stated in a variety of ways by different writers. Professors Letts and Adeney, who have done much work for English authorities, measure it in c. c. per litre. Prof. Earle B. Phelps, who has been engaged on the waters of New York harbor has used "grains per cu. ft." and percentages of saturation; in connection with investigations into the condition
2266 of the Chicago Drainage Canal, "parts per million" is used.

I have taken the following table from the New York Sewerage Commissioners report, page 410, which shows the cubic centimeters per litre and percentages of fresh water and for different temperatures from 63 to 79 Fahrenheit or 17 to 26 Centigrade, and with different percentages of fresh water.

Approx. Fahr. added by D. F.	cc. per litre.		Percentages of fresh water.				
	Fahr.	C	0	20%	40%	64%	100%
	63	17	5.6	5.9	6.1	6.4	6.9
	65	18	5.5	5.8	6.0	6.3	6.8
	66	19	5.4	5.6	5.9	6.2	6.7
	68	20	5.3	5.5	5.8	6.0	6.5
	70	21	5.2	5.4	5.7	6.0	6.4
	72	22	5.1	5.4	5.6	5.8	6.3
	73	23	5.0	5.2	5.6	5.8	6.2
	75	24	4.9	5.2	5.4	5.6	6.1
	77	25	4.9	5.1	5.4	5.6	6.0
	79	26	4.8	5.1	5.3	5.5	5.9

NOTES.—Add 4/10 to these figures to reduce to "Parts per million," or multiply by 1.4, as follows: Weight of oxygen, say 0.0014 grammes per cc.; then if we multiply the cc. per litre by .0014 we shall have the parts by weight in 1,000, because there are 1,000 cc. in a litre and if we multiply the product by 1,000 we shall have "parts per million."

Q. These percentages vary with the temperature?

A. With the temperature and with the percentage of fresh water, in this table from 6.9 cubic centimeters per litre to less than 5, or 4.8.

Q. Proceed, give your reasons for the opinions you have expressed?

A. In the recent "Report on Sewage Disposal, The Sanitary District of Chicago made to the Board of Trustees by George W. Wisner, Oct. 12, 1911," we have one of the best professional discussions on the relations between sewage and dissolved oxygen which has appeared in this country, largely arising from the fact that
2267 Chicago has had more experience than any other city in the actual handling of enormous quantities of sewage, in which dilution plays the important part. With many facts about Chicago Drainage Canal I am intimately acquainted.

Q. You are?

—. Yes.

Q. How did you become acquainted with those facts relative to the Chicago Drainage Canal?

A. I once worked for the State of Illinois for six months on the Canal and made a report of 131 printed pages. Since that time I have served on a Commission of experts for the City of Joliet in connection with the development of the water power.

I have examined that report carefully and I have made some computations on the basis of their observations there, and in my opinion the result of these observations in Chicago pointed to the percentage of 50% as being desirable, and particularly in reference or in connection with the maintenance of fish life, and it so happened that that is the same percentage that I myself had adopted before I had seen that report. In fact, that is in writing, so that I am very strongly of the opinion that it is very desirable that we should consider 50% as a minimum standard below which the waters of the harbor, all the waters surrounding New York, should not be allowed to be depleted of their oxygen.

Q. Below what point?

A. Below 50%. I am of the opinion that an important fact to bear in mind in this connection is that it takes several years to install a sewage system on as large a scale as will be necessary in the case of New York harbor, even after one is adopted and authorized—so that, with the large increase in the population, there should be some safe margin over and above the 50%. From this point of view, this standard does not seem large enough, especially as today in the summer, the Hudson, in a section from the Battery to the
2268 Jersey shore, has about reached that minimum standard.

The second important reason in my opinion why New Jersey should not be allowed to discharge this sewage into the middle of

Upper Bay or into the Upper Bay in the vicinity of Robbins Reef is that it will dangerously diminish the dissolved oxygen in the waters.

If New Jersey is allowed to discharge the sewage of the Passaic Valley as proposed by a tunnel to Robbins Reef in the Upper Bay, it will add to the present load of pollution carried by the waters of the Upper Bay to such an extent as to diminish dangerously the dissolved oxygen in the water.

In the summer of 1911, the average of 117 samples taken in the vicinity of Robbins Reef showed a presence of but 73% of the full complement of dissolved oxygen.

In regard to the probable quantity, the engineers for the Passaic project place the maximum capacity of their trunk sewer scheme at 375,365,200 gallons with sewer ¾ full. It is stated by the New Jersey authorities that it will be possible to make use of the large capacity (or "extra size" as they put it) by "admitting a more dilute sewage from the combined sewers of Paterson, Newark and elsewhere than can later be admitted."

Q. That is taken from what?

A. Their report.

Q. Whose report?

A. The commissioners' report.

Q. The Passaic Valley Sewerage Commissioners?

A. The Passaic Valley Sewerage Commissioners report; and they further state that in the connections the overflow shall be so arranged that during rain storms "the excess of storm water beyond that quantity for which the district sewer is designed can flow directly into the Passaic River," and again, "the regulators automatically close during a rain storm, after the main sewer has been filled to a certain height with the first washing of the local sewers and allow the balance of the water (practically rain water) to pass
2269 through the overflow to the river."

The Commissioners enforce this matter as follows: "this plan will make available the full capacity of the main sewer at once."

Mr. Riker: I object to what he is reading. I object to further questions on this report on the ground that the report, if it is evidence, should be proved in this cause.

The Commissioner: Note the objection of counsel for defendants.

Q. Proceed Mr. FitzGerald?

A. Taking the total capacity of the 13′ 6″ sewer as about 400,000,000 gallons daily, it is probable that at time, immediately on the installation of the system, that amount of sewage will be discharged into the Upper Bay. A discharge of 400,000,000 in 24 hours is at the rate of more than 16,600,000 gallons per hour.

Sq. miles. The total discharge in a day of this amount of sewage would theoretically cover an area of 3.8 square miles with a mass of sewage 6″ deep, and in one hour, say at slack tide, it would cover more than 100 acres 6″ deep.

It will be remembered that this is continuous discharge for many hours at a time.

Its nature: We have an index to a certain degree of the nature of this sewage from the Passaic engineers who designed the scheme. They state that of the total discharge 62,482,000 is trade wastes, and 47,400,000 m. g. daily is ground water, leaving 247,483,200 for the sewage. Total: 357,365,200 m. g. daily, about 1/6 trade wastes and about ⅛ ground water. From the large amount of trade wastes in the Passaic Valley, the sewage will be very strong and offensive.

Some eminent experts, Winslow and Phelps, consider than
2270 an allowance of 800 parts per million for the total solids is a liberal one in American cities. It is probable that the total solids in Passaic sewage will not rise much above 900 parts of which 70% or thereabouts will be in solution, liquid and colloidal, and 30% or thereabouts in suspension, or 630 parts per M. in solution and 270 in suspension. The usual velocities in local sewers when running full or half full, say on the average 2 feet per second from house connections to sewer, distance is often 2-3 miles in cities. The hourly variation in flow may vary from 70% to 135%. The discharge of the N. Met. System in Boston is about 12 125 m. g. daily. The area of a 13½ ft. sewer is about 130 sq. ft. x 5 ft. per second 650 c. f. s. Slope about 2 feet to the mile. At upper end, ¾ x 12 sq. ft. 9 sq. ft.—9 x 2.6 23 c. f. s. 15.3 m. g. daily. In regard to the latter, the average amount of suspended matter is generally stated to equal 100 grams per capita, which is 264 parts per million, which is a close agreement with the above 270; also Baltimore is said to have 90 grams per capita of suspended matter. I am therefore of the opinion that I have formed and I find that Hazen has given the total solids in Paterson sewage as 360 grams per capita.

Mr. Riker: I move to strike that out as hearsay.

The Commissioner: Note the motion of counsel for defendants.

Q. Did Mr. Hazen to your knowledge conduct an investigation relative to the sewage disposal of the City of Paterson for the municipal authorities of that city?

A. I have seen his report.

Q. It is published as a municipal official document?

A. I do not remember.

Q. You may proceed, Mr. FitzGerald?

A. It is generally considered that these 900 parts which I have
2271 given ½ of 900 parts is chiefly organic matter, because it can be driven off by heat; ½ of 900 parts is chiefly mineral, 75% in dissolved state.

Whole length of sewer to pumping station=110,000′ or about 21 miles. From pumping station to outlet=27,000 ft.=5.1 miles (according to the statistics given in the report of the Passaic Sewerage Commission). The velocity of flow at the upper end of the sewer, where it is 4 ft. diameter, will be from 2.6 to 2.9 ft. per second and it gradually increases as the sewer enlarges until at Newark, where the diameter is 13½ feet, it becomes about 5 feet per second. The sewage will be at least ten hours old when it reaches the tanks. It will be much broken up, finely divided. The screens and settling of one hour will have little effect on the liquid and colloidal matter

and a large part of the finer matter will not settle in that time. It is usual in large systems, where it is expected to intercept from 60% to 70% of the suspended matter, to allow for a quiet subsidence of about 6–8 hours.

I may say here that in large cities the usual practice recently has been to allow from 6 to 8 hours detention for subsidence.

It seems to me a one hour settling can hardly be called efficient sedimentation. The removal of the suspended matter can hardly be expected to reach a greater percentage than 40 and it will, in my opinion, be nearer 30.

From the settling tanks the sewage must then flow through 27,000 feet or 5.1 miles of tunnel, etc., to the outlet at Robbins Reef, which will take two hours more, or about twelve hours' flow altogether, and probably this will generally be nearer 14 hours.

As the oxygen in the vicinity of Robbins Reef has already been reduced 27% in the summer, it will undoubtedly be dangerously lowered, how much, it is difficult to say. At the present
2272 time, the water of the Upper Bay passes up the Hudson and into the East River, refreshing those waters and furnishing them with its dissolved oxygen; any lowering of that oxygen, especially in the summer season will result in a rapid increase in the pollution of the waters surrounding New York and Brooklyn to say nothing of the increased load of filth in the Upper Bay itself.

If this sewer was in existance today, and discharging at times nearly 400 million gallons daily into the Upper Bay at Robbins Reef, the effect would be to lower the dissolved oxygen in the Hudson River below the standard of 50% and it would also reduce the dissolved oxygen dangerously all around its borders and in the East River—and it would inevitably destroy the safe margin of safety now existing in the central bulk of Upper Bay water. This would certainly be a dangerous condition in my opinion for New York Harbor.

If authority were obtained at once to build the Passaic Valley sewerage scheme, it would take several years to construct and install, in working order, so large an undertaking.

By the time it is installed, so rapidly is the population of the Metropolitan District growing that the dissolved oxygen will be still farther depleted in the harbor waters.

Mr. Riker: I move to strike these last remarks out on the ground that it is argument and not testimony of an expert upon facts.

The Commissioner: Note the motion of counsel for defendants.

Q. Proceed Mr. FitzGerald.

A. As there is now in and around the waters of the Upper Bay hardly enough margin for safety to take care of the crude sewage now discharged into these waters in the summer season, New Jersey should not be allowed to discharge the sewage of the Passaic Valley at Robbins Reef, because it will dangerously diminish the
2273 amount of dissolved oxygen in the water, and this danger will increase with the advancing years.

Mr. Riker: I object to giving this testimony in narrative form without any question on the ground that it is not responsive to any question that is propounded to the witness that will be subject to objection.

The Commissioner: Note the objection of counsel for defendants.

Q. Are you stating your reasons for the opinion which you have expressed, Mr. Fitz Gerald.

A. I am.

Q. Proceed, please.

Mr. Riker: The objection is renewed, as that does not give the basis for any objection to the specific form of the testimony which this witness is attempting to introduce in this cause.

The Commissioner: Note the further objection of counsel for defendants.

Q. How would you describe the Upper Bay, New York Upper Bay?

Mr. Riker: The question is objected to on the ground that it is not specific enough to show that it has any reference to the matter of this controversy.

The Commissioner: Note the objection of counsel for the defendants.

A. I should describe the Upper Bay as really an enlarged continuation of the Hudson and East Rivers which enter it close together at the upper or northerly portion.

Q. And the two rivers, there is an area of land separating them?

Mr. Riker: Same objection.

The Commissioner: Note the objection of counsel for defendants.

2274 A. Between these two rivers is a long narrow strip of land known as Manhattan Island and it contains New York City proper. Brooklyn forms the Easterly boundary of Upper Bay and Jersey City, Bayonne, Kill van Kull and Staten Island bound the westerly side, while to the south we have Staten Island and the Narrows. The third important reason that you have asked me to give why New Jersey should not be allowed to discharge that Passaic Valley sewage into the Upper Bay is because the sewage will be driven by wind and currents to the surrounding shores and it seems to me important in this connection to consider, to bear in mind these boundaries that I have mentioned, on the South Staten Island and the Narrows, and that the Upper Bay is a large basin of water, 21 square miles in area, interposed between the rivers mentioned and the Lower Bay. It has a length of about 7 miles; at its northerly end just below the mouths of the Hudson and East Rivers, it is about 3 miles wide; in its widest portion, it is 4¼ miles wide and at the Narrows, it is a little under one mile wide. This basin is deep throughout its central portion, in the channel, but is very shallow on the westerly side. For instance, a section through the central portion, at Robbins Reef shows 2½ miles of water with an

average depth of 6¼ at L. W. Then a mile averaging 36′—then ¾ mile 20½—35′. Total 4¼ miles across. In other words, more than ½ of the bay is flats covered with 6¼′ at low water.

Into this intermediate reservoir with a tide of 4.4′ the Hudson, a mile wide, pours a large stream of fresh water; but the East River has very little resultant flow—the water here simply, as a rule, rushes backward and forward. At the southerly end, the sea water comes in through the Narrows mixed with the old water of the preceding ebb.

The upper Bay is the great mixing basin of the system and the percentages of land and sea water that it contains will depend largely upon the flow of the Hudson River.

2275 At 1 P. M., adjourned for noon recess until 2 P. M.

CORPORATION COUNSEL'S OFFICE,
NEW YORK, July 19, 1912—2 o'clock p. m.

DESMOND FITZGERALD, a witness called on behalf of complainants, recalled for further examination, testified as follows:

Direct examination by Mr. O'Sullivan (resumed):

Q. Proceed from where you left off at recess, Mr. FitzGerald.

A. If it could be emptied the deep trough running lengthwise through it, evidently an old extension of the Hudson Valley into the sea. The Upper Bay, is about 15 miles long; about 8 miles north of the bay the Harlem River, a narrow strait, enters the East River and connects with the Hudson. The Harlem is about 7 miles long and extends north and south. The northerly extremity of the East River is at Throgs Neck and here it is lost in Long Island Sound.

Upper New York Bay has another important connection, i. e., with Newark Bay by way of the Kill van Kull, a short strait, nearly ½ mile wide and 3 miles long. Newark Bay is a shallow body of water 4¼ miles long and nearly two miles *tide*—and has an extension, the Arthur Kill, a narrow strait around the westerly side of Staten Island.

The water from the Lower Bay or ocean rushes through the Narrows into the Upper Bay and then up the Hudson and East Rivers and the Kill van Kull, while three hours later, another flood tide enters East River at Throgs Neck and makes its way towards Hell Gate. At Throgs Neck too, the mean tidal range is 7.3′ while in the Upper Bay it is but 4.4′. The violent velocities at Hell Gate
2276 are the result of these interfering tides.

Q. Have any experiments been conducted that you have examined in their plotted form to determine the direction and strength of the currents in this body of water?

A. Yes. Experiments to determine the directions and strength of the currents were made by the Mtropolitan Sewerage Commission in 1907-8-9. Twenty-seven of these were made in 1907, 39 in 1908 and 25 in 1909.

Q. And you have examined these exhibits?

A. Yes. Of course, they vary very much, but there is something

to be learned from them. Many hug the shore of Staten Island on the ebb tide and some floats put into the Upper Bay not far from Robbins Reef pass up into the Hudson River beyond Fiftieth or Sixtieth streets. For instance, Float No. 34 drifted from near Robbins Reef to West Sixtieth street, Manhattan, 9.14 miles, in 6 hours, 18 minutes. Float No. 37 drifted from near Robbins Reef to Bank street, Manhattan, 6.85 miles, in 6 hours and 20 minutes.

As sewage is warmer than the Upper Bay water, it will naturally rise to the surface forming what is called a "field." In such position it will be acted upon by the winds with great effect.

From a consideration of these facts, I am of the opinion that with flood currents the sewage, if discharged at Robbins Reef, will be driven long distances up the Hudson and East Rivers on both fronts of Manhattan and to the Brooklyn shore—irrespective of the winds. When the wind is blowing from the Southwest or West this movement will necessarily be hastened. The distance from Robbins Reef to the Battery is not far from 4 miles and there will be many times when the sewage may be expected to arrive in from two to three hours from the tidal influences alone. The time will be re-
2277 duced by favorable winds. Instead therefore of having the advantage of being refreshed with water from the great mixing and distributing reservoir of the Upper Bay with a good percentage of dissolved oxygen to aid in the purification of their sewage discharges, the shores will be attacked by a more highly polluted water, more deficient in dissolved oxygen and will then be robbed of their natural purifying influences which they now enjoy.

Q. What other injurious consequences would be causing an unsanitary condition of the harbor waters besides those you have given that might be expected?

A. I am of the opinion that it will injuriously affect commercial interests. I think that this injurious consequence of the unsanitary condition of the harbor waters has been realized by the legislature of New York. I quote from the Metropolitan Sewerage Commission's Report.

Mr. Riker: I object to the quotation on the ground that it is only hearsay. It is not material or relevant to this case.

The Commissioner: Note the objection of counsel for defendants.

Q. From what do you quote, did you say?

A. In connection with this position of the legislature, I have a quotation from the Metropolitan Sewerage Commission's report.

Q. The Metropolitan Sewerage Commission of New York?

A. Of New York.

Q. Proceed, please.

A. Among the specific questions raised by the Legislature in the Act which provided for the creation of a Metropolitan Sewerage Commission, report of New York, were the following: "Is it desirable to establish a sewerage district in order properly to dispose of the wastes, and adequately protect the purity of the waters contemplated in this Act, and, if so, what should be the limits and boundaries of

this sewerage district?" to which the Commission responded
2278 that it was desirable. They recommended a general plan for conservancy and recommended the interception of a large part of the sewage draining into the Harlem River and East River "in order to do away with the nuisances now existing in these streams," and they further recommended studies for other works which are now in progress.

It seems to me the importance of the commercial interests connected with the Port of New York can be realized by trips around the harbor front and examining the enormous development of public and private interests depending upon commercial relations for their existance. It can be realized in another way but not so well; that is by studying the statistics of the other great ports of the world and comparing them with New York. I have had the advantage of doing both, and have visited other great ports for the purpose of studying their development and have reported the results to the Legislature of Massachusetts and have made plans for the future enlargement and development of the port of Boston.

Q. What ports in Europe did you visit?

A. Among the other great ports are Hamburg, Liverpool, London, Rotterdam, Antwerp, Bremen, Havre, etc., but the commerce of the port of New York now leads all of these in the extent and variety of its traffic. This commerce is growing with leaps and bounds and is in reality the most important in the world.

In my opinion already the filthy condition of the water in the harbor injuriously affects some of the commercial interests and if it is allowed to grow worse, as it is now rapidly doing with the increase in population and the increase in the volume of drainage, it will soon become intolerable. As the dissolved oxygen in the water becomes used up the harbor will rapidly approach the condition of
2279 an open sewer or cesspool, giving out bad smelling odors and causing damages of one kind or another to every one navigating the waters.

I have another reason for believing, import- reasons, for believing that the state of New Jersey should not be allowed to discharge this sewage on account of its being an unnatural outlet for the Passaic Valley sewage.

The natural outlet for Passaic Valley sewage is the Passaic River. Towards this river the slopes descend and as a consequence here the pollution all collects. The present sewers of the valley from Paterson to Newark empty their load of crude sewage into the river without any attempt at purification and in consequence the river at its lower end is practically devoid of dissolved oxygen. It is little better than an open sewer and in fact in many respects much worse because it gives out noxious smells due to an advanced state of decomposition.

Passaic River empties into the upper end of Newark Bay which finally discharges through Kill van Kull (84% of its water) into the Upper Bay by a roundabout course. During the passage through Newark Bay the sewage is purified so that the amount of dissolved oxygen at the lower portion of the Bay is 64% of saturation, or somewhat better than the Hudson River at the Battery. This percentage

would be very much higher if some form of purification were adopted along the Passaic Valley before discharging into the river: in fact the effluent water from the sewers, after purification, may be turned into the river at any standard of purity which may be found desirable in connection with the river.

It is now proposed by the New Jersey authorities to intercept this sewage, tunnel under Newark Bay, Jersey City and Bayonne, thus making an artificial passage under the barrier naturally existing between Newark Bay and the Upper Bay of New York Harbor and at great expense extending this tunnel to or near Robbins
2280 Reef and discharging the whole Passaic sewage into an unnatural outlet in New York Harbor to the detriment of the State of New York. This is an unnatural advantage, one not afforded by nature or topographical situation, and in my opinion should not be allowed for one portion of the Metropolitan District as against the rest. In my opinion all should take an equal part in some well considered plan devised after careful thought and acting for the benefit of the whole.

Many complaints have been made from time to time in the past against the dumping of solid matter into the harbor. (The terminus practically of every import- line of railroad in North America. p. 5, Vol. 38, No. 1 A. S. C. E., the best and largest ships of all the lines come here; Panama Canal and New York State Barge Canal when completed will increase the numbers.) Against this practice there are laws and regulations. Jurisdiction in this respect is exercised by the General Government and there is a special bureau of the War Department which takes this matter in charge in New York. This is in the general interests of navigation, on account of the filling up of the channels and the consequent diminution in the depth of the water.

An Act of Congress has been passed June 29, 1888, to prevent injurious deposits in New York Harbor. There is a Supervisor in the harbor with an organization of men and boats costing, it is stated, $150,000 annually. (p. 502 Commr. Report). Through the interference of the Government in the Passaic Valley Case, some of the solids are to be intercepted as already described.

This action is in the general interests of navigation, but the Government has taken no action against the solids transported in suspension by the sewers entering the bay.

2281 Q. In your studies of the Passaic Valley sewerage project, did you find that any of the communities which were to contribute sewage to that trunk sewer were riparian communities?

A. I think not. I could not find that any were. I should say that none of the sewage from the Passaic Valley which it is now proposed to intercept under the scheme devised by the Passaic Valley Sewerage authorities and discharge directly into the Upper Bay, is riparian sewage: that is to say, it is composed of the sewage discharges from communities none of which are riparian to the Upper Bay and some of them are 26 miles distant from the point of discharge.

Passaic River discharges into Newark Bay. None of the people

comprised in the sewerage scheme live upon the borders of the Upper Bay. The principal cities involved in the plan are Paterson, Passaic and Newark and 27 smaller towns and boroughs on the water shed of the Passaic and far removed from the Upper Bay. The very word riparian is derived from "ripa—a bank" and the true meaning of the word is "of or pertaining to the bank of a river"—"riparian proprietor, one who owns land bounded by a stream or other water."

Q. Did you understand my question limited itself to those communities that are riparian on the Upper Bay?

A. I did. In this case, we have a large inland community which proposes to tunnel under their natural outlet Passaic River and Newark Bay and under the separating land of Bayonne and Jersey City and discharge their sewage close to the water boundary between New York and New Jersey in such a manner as to do a great injury to the real riparian owners and occupants of valuable property around the shores.

Q. From what you have described and the studies that you have made would you expect the discharge of the Passaic Valley trunk sewer outfall, the sewage from that, to cause a nuisance?

A. I should.

2282 Q. What do you base that opinion on?

A. I think that Mr. Rudolph Hering is one of the experts on this Passaic Valley scheme and he has made a very interesting and appropriate heading in connection with this subject in one of his reports in which he states, I quote there——

Mr. Riker: I object to the quotation from Mr. Hering's report on the ground that it is not material.

The Commissioner: Note the objection of counsel for defendants.

A. He says: "From the time of the Roman cloaca maxima, sewage has been considered a nuisance. During modern times, it has also been recognized as a disease carrier."

Q. Have you made any computations based in the populations and the per capita sewage and the volume of sewage?

A. I have.

Q. In relation to the Passaic Valley Sewerage project?

A. I have. I have made the following estimate of the population and the probable amount of sewage that may be expected of the communities in the states of New York and New Jersey now discharging sewage into New York Harbor within the Metropolitan Sewerage District. The estimate is based on figures in "Basic Data."

Q. They are already in evidence in this case and marked as complainants' exhibits?

A. Yes. The populations vary as shown in this table:

	Population.	Sewage, gallons, daily.	
1910 ...	6,377,743	797,000,000	Increase based on 26% for 10 years.
1911 ...	6,500,000	812,500,000	
1912 ...	6,700,000	837,500,000	
1918 ...	7,600,000	950,000,000	
1920 ...	8,000,000	1,000,000,000	
1940 ...	12,733,560	1,600,000,000	

2283 In round numbers, the population in 1911 when the last dissolved oxygen samples were collected, was 6½ millions and the sewage 800,000,000 gallons daily. If authority were obtained without unnecessary delay for the construction of the Passaic sewerage scheme, it is not probable that it would be installed in full working order before 1918. Hazen, in his Pittsburgh Report, says it would take from six to eight years to install the Pittsburgh plan. It usually takes several years to complete a large engineering undertaking of this importance. By that time, the population would have increased to 7,600,000 and the sewage to 950,000,000 gallons daily, an increase of about 18%.

Q. The population in what area?

A. The whole Metropolitan District.

Q. The Metropolitan Sewerage District?

A. Yes.

Q. That would include parts of the State of New York and parts of the State of New Jersey?

A. Yes.

Q. All right, sir.

A. That is the population and the sewage would have been increased about 18% over that in 1910.

Q. How much would that increase the sewage?

A. Well, proportionately, I assume it would increase it proportionately.

Q. Have you made any computation?

A. None of the sewage discharged. The quantity is based on the populations?

Q. Based on a population of 7,600,000 how much do you estimate the sewage?

A. 950,000,000 daily. To form an idea of the effect of diverting the sewage in the Passaic Valley, directly to Robbin's Reef, as proposed, it will be important to consider first the present effects upon the Upper Bay of New York Harbor by the present method of discharge of this sewage into Passaic River all along its course to its mouth at Newark Bay. The Passaic River is acknowledged by all to be at present an elongated cesspool in which the sewage is
2284 retained until all of the oxygen in the water is practically used up in the processes of putrefaction. As the fresher sea water is brought up Newark Bay, its oxygen is in turn used in the purifying process and finally the sewage after passing through Newark Bay with its 8.35 square miles of water area is discharged into the Kills—16% passing into Arthur Kill and the Lower Bay, and 84% into Kill van Kull and after a passage through that Kill, is discharged into Upper Bay. The dissolved oxygen present is then 64% at the lower part of Newark Bay and probably about 70% at the mouth of the Kill, as 117 samples in the vicinity of Robbin's Reef gave 73% in both currents in 1911.

Q. As shown by complainants' Exhibits Nos. 31 and 34 in the tabulations of oxygen?

A. Yes. In 1918, the population of the Passaic Sewerage District which was 734,396 in 1910, will have increased to about 900,000 in

1918 with about 112,500,000 gallons of sewage daily, which was included in the total of 950,000,000 gallons daily in 1918 of the whole Metropolitan District. If the Passaic sewage is deducted, this will leave 838,000,000 in round numbers.

This estimate assumes that in 1918, Passaic sewage, if discharged as at present, will have but little effect upon the lowering of dissolved oxygen in Upper Bay; 16% will never reach it and the other 84% will be acted upon to such an extent in Newark Bay and Kill van Kull as not to call upon the dissolved oxygen in Upper Bay materially after its entrance. The area of Newark Bay and the Kull is almost half that of the Upper Bay itself, so that the opportunities for purification are excellent in 84% discharged finally near Robbin's Reef.

With the completion of the proposed Passaic tunnel, however, the whole of the Passaic sewage will be discharged directly into
2285 one portion of the Upper Bay, near Robbin's Reef. In 1918 the proportional part of the Passaic sewage at that time will be 112,500,000 gallons daily, or about 13% of all the rest of the sewage tributary to the Upper Bay, Hudson River, East River and Harlem River. This amount of sewage collected in one spot would be sufficient to create a seriously objectionable condition. With a general increase of all the sewage of the District at that time of 18% and a farther diversion and concentration of 112,500,000 which under natural conditions could not be expected to do much injury to the waters of Upper Bay and which would amount to 13% of the rest of the sewage, we have conditions which cannot fail to make a very serious reduction in the dissolved oxygen.

There is another feature of this tunnel plan which cannot fail to create alarm. The total capacity of the tunnel scheme is more than 400,000,000 gallons daily, and that it is probable from the statements of the Passaic Commissioners and their engineers, that the full capacity of the tunnel will be utilized on completion of the works. This means of course, that, instead of throttling the connections of all the sewers so as only to admit a pro rata amount of sewage, rain water rushing from the streets (which makes a very foul effluent) and the scouring out of any settlings remaining in the local sewers before the rain begins, will all be added to the flow of the main interceptor up to its maximum capacity, that is to say after any rain on the Passaic water shed, there will flow into the Upper Bay not 112,500,000 gallons in 24 hours, but more than 400,000,000 gallons in 24 hours. I am of the opinion that this amount of filth (the Passaic report described the capacity of the sewer as made up of "sewage and other polluting matter") discharged practically at one spot in the Upper Bay will create a local and general nuisance.

2286 This amount of sewage concentrated in the neighborhood of Robbin's Reef will create a local nuisance which in a few hours under the action of the winds and currents, will be carried to any of the surrounding shores—thus producing a long series of general nuisances in every part of the harbor—which prospectively will increase in intensity as the sewage becomes less diluted and the dissolved oxygen in the Upper Bay is carried lower and lower.

These nuisances, in my opinion, will result in a substantial injury to the harbor of New York and to its waters in connection with the uses for which they are now and always will be extremely valuable.

Q. Mr. Fitz Gerald, I would like now to direct your attention to the stipulation entered into between the State of New Jersey and the Federal Government, Complainants' Exhibit No. 135, and I ask you to take that stipulation into consideration and see if it modifies any of the expressed opinions that you have just testified to?

Mr. Riker: I object to it on the ground that the stipulation is involved in a hypothetical question which has already been propounded to this witness, and that his testimony as to it, except in connection with the hypothesis is not material or relevant to this inquiry.

The Commissioner: Note the objection of counsel for defendants.

Q. You may answer, Mr. Fitz Gerald?

A. It does not.

Q. Will you state what study and analysis you subjected Complainant's Exhibit No. 135 to?

A. I studied it carefully, and I found when the Passaic Valley Sewerage Commission, in 1908, applied to the Secretary of War, in conformity with the requirements of the navigation law, for
2287 a permit to construct the outflow tunnel under the navigable waters of New York Bay, etc., the matter was referred to the Harbor Line Board and pending a decision, the New Jersey authorities offered to amend their plan by introducing settling basins, etc., but the modification was declined by the Attorney General of New York State. In October, 1908, the Attorney General of the United States filed a petition which resulted finally in an "Agreement" between the Government and the State of New Jersey. By this agreement, it is provided that the sewage—

1st. Shall first pass through coarse screens.

2nd. A grit basin or basins.

3rd. Self cleaning mechanical screens 4/10" opening.

4th. Sedimentation basins or units 225' long by 15' deep. Approximately of 1,250,000 gallons capacity and detention period until 1920 of not less than one hour at maximum rate of flow and 1½ hours in 1920 at the average flow. The lineal velocities until 1920 not to be over 0.5 inch per second for the maximum flow.

5th. Scum boards and devices for removing deposits.

6th. Series of outlets 40 feet below L. W. Four or more discharge pipes across the current 100' apart decreasing from 6' to 2' with 150 or more T's not more than 1' diameter 10' apart (about) covering at least 3.5 acres.

At all times the following results shall be secured:

1st. Absence of visable suspended particles in New York Bay coming from this sewage.

2nd. Absence of deposits objectionable to the Secretary of War.

3rd. Absence of odors due to putrefaction.

4th. Practical absence on the surface of any grease or color.
2288 5th. No injury to the public health and no public or private nuisance.

6th. Absence of injurious effect upon U. S. property in harbor.

7th. "The absence of reduction in the dissolved oxygen contents of the waters of New York Bay, resulting from the discharge of Passaic Valley sewage, to such an extent as to interfere with major fish life."

The Secretary of War to inspect and call for assistance to aid inspection. I am of the opinion of these seven rigid standards of purity or of absence of effects upon the waters of the Upper Bay No. 2 provides that there shall be absence of deposits objectionable to the Secretary of War. As far as the other six are concerned, it will be practically impossible to prove that the evil results which in my opinion are sure to arrive, can be traced to the Passaic sewage after that has once become mixed with the waters of the Upper Bay. That that body of water is as I have already testified the great mixing basin of all the waters of the harbor. Into this basin discharge the waters from the Hudson and East Rivers on the North, and into it from the south pour the Lower Bay waters. Into it will also discharge more than twice as much other sewage from New York, Brooklyn, etc., outside of the Passaic. Therefore, in at least six of these standards, the interests of New York are not safeguarded in a practical manner.

As to No. 2 the deposits in the Upper Bay might not be objectionable to the Secretary of War from the point of navigation, when they might be objectionable from their effects on lowering the oxygen in the water due to putrefaction.

2289 The more thoroughly I have considered the conditions of this stipulation, the more definitely that, in no respects does it safeguard the interests of the harbor. It with one hand, specifically allows to be carried out a system of sewage discharge on an enormous scale, while with the other hand, it denies the power to pollute the waters of the Bay—a result which is sure to arrive, but which it will be difficult if not impossible to prove.

I am of the opinion the War Department is not a tribunal which should be called upon to decide an important sanitary measure of this nature. Such matters are usually left to Courts or Boards of Health to determine—bodies which have tried and skilled experts or corps of assistants capable of passing upon great sanitary plans—and it can hardly be expected that the interests of New York are properly safeguarded when the decision of the harmful results is left to the same authorities which grants the permit to discharge the sewage, and this I state can be maintained without implying the slightest disrespect to the Secretary of War or his Assistants.

Q. Have you studied any more feasible scheme of disposing of the Passaic Valley sewerage than the one just described?

Mr. Riker: The question is objected to *as* on the ground it is not material to this inquiry.

The Commissioner: Note the objection of counsel for defendants.

A. I have.

Q. State what study you have given to that phase of the subject?

A. I have found that an economical solution for their sewage

problems has agitated the inhabitants of the Passaic Valley for many years. In the meantime, the pollution of the river into
2290 which the sewage is discharged has increased rapidly until it has become an intolerable nuisance—at least in the lower parts of the river, especially through the City of Newark.

The plan of intercepting and gathering all the sewage of the valley and discharging it into the Upper Bay of New York Harbor is only one of the many plans which have been proposed by sanitary engineers.

In January, 1903, Mr. Samuel M. Gray reported to the Citizens Association of Paterson.

Q. Made a report to whom?

A. He was selected by the Citizens Association of Paterson and he reported that the sewage of that city could be disposed of independently and in such a manner as not to cause a nuisance to anyone.

Q. Briefly state what were his recommendations?

A. His recommendations were in brief to locate a plant, consisting of septic tanks and sprinkling filters upon land in Bergen County, on the east side of the river, a short distance northerly of the City of Passaic, the sewage to be collected by an intercepting sewer in Paterson flowing to the purification works by gravity and being pumped thence into the septic tanks, the estimated cost for a daily capacity of 25,000,000 gallons, together with the interceptor "was $2,670,185; the annual cost of operation not over $180,435. In 1903 Mr. Hering's alternate plan for solving the Passaic Valley sewage problem was by a "system" of intercepting sewers, similar to those of the first plan, but instead of crude disposal into New York Bay, the second plan includes the use of one or more purification plants in which the sewage should be treated and the purified effluent discharged into the Passaic River or Newark Bay."

In 1906 Mr. Allen Hazen studied the whole matter of disposing of Paterson's sewage independently and compared the cost
2291 with the trunk sewer project, the total annual cost per capita being $1.38 for separate works and $0.95 for the trunk sewer project. His purification plant was designed on the same general plan as that for Columbus and Baltimore. It must be remembered, however, that, if the settling tanks since added by the Secretary of War to the Trunk Sewer Project be taken into account, the economy would probably have been reversed.

In 1910, Mr. Harrison P. Eddy made a careful study for the disposal of the sewage of East Orange; East Orange and Montclair and of East Orange, Orange, Montclair, Bloomfield and Glen Ridge. I quote from his report.

Mr. Riker: I object to any evidence as to this particular group of municipalities which have not signed the contract and not involved in this project. I object to it on the ground it is immaterial and irrelevant.

The Commissioner: Note the objection of counsel for defendants.

Q. Proceed, Mr. FitzGerald.

A. Under the head of "Location of Purification Works," he says,

"Several suitable locations appear to be available for such works. Some are so located that the effluent would be discharged into the Passaic River, while others are so located as to require the effluent to be discharged into the Hackensack River. The available locations adjacent to the Passaic River are few, and the major portion of this report is based upon the assumption that it will be necessary to locate the purification plant at some more distant points upon the salt march of the Hackensack River."

The population provided for in 1940 was 240,980, and the total cost 1930-'40 $29,887 yearly for all five municipalities. Sprinkling filters were the main feature of the plan.

2292 The slight difference existing between the cost of local purification and local discharge of the effluent, after treatment, into the Passaic River may in my opinion *should* cause some of the municipalities to pause and consider whether it is best to enter the Passaic Trunk sewer plan. Some of them, as we know, have been investigating this matter and it may prove true that, for many of them, since the costly addition of settling tanks at the pumping station, made necessary by the action of the Government, that, on the ground of cost alone, the trunk sewer may prove the less acceptable method.

The whole progress made in purification processes in recent years has been in the direction of reducing the area required for purification and the cost of treatment. The problem of disposing of the sludge, which was formerly one of the difficult and offensive obstacles, has been largely overcome by the very recent advances involved in sewage purification. Many plants erected and experiments made on a large scale have demonstrated that sprinkling filters can take care of 2,000,000 to 3,000,000 gallons per day upon an acre of land—so that by this process large cities are building works on the basis of 40 acres for the sprinkling filters. Baltimore is a notable example. By several processes the effluent can be turned into the stream at any required standard of purification, within reasonable limits. The difficulty of finding sufficient area of unoccupied or worthless land no longer stares the sanitary engineer in the face.

In view of the probability that all of the sewage of the Passaic Valley could be disposed of by scientifically planned systems of purification and the effluents discharged into the tributaries naturally connected with Newark Bay, it seems unreasonable to inter-

2293 cept and discharge this sewage into the Upper Bay of New York Harbor, where its effects will be so detrimental to the public welfare.

Q. Have you given all the reasons for your opinion, Mr. Fitz Gerald?

A. There are others, I think.

Q. What others?

A. Well, I think a strong reason for not allowing New Jersey to pour this mass of sewage into New York Harbor near Robbins Reef is because New York is now planning for the proper disposal of the sewage of the whole Metropolitan District, and before any plans

can be put into effect the sewage will probably be fifty per cent greater than in 1910.

Q. What do you base that on?

A. I base it largely on the fact that the State of New York and the City of New York, the legislature I should say of the State of New York has continued the life of the commission.

Q. What commission?

A. The Metropolitan Improvement Commission of New York.

Q. The Metropolitan Sewerage Commission of New York?

A. The Metropolitan Sewerage Commission of New York, for three years, in order that the commission "might make plans and estimates of cost for such main drainage works for New York as its investigations had shown to be necessary."

A preliminary report No. 1 and dated September, 1911, covered the feasibility of collecting all the sewage of New York at one central point for disposal and this report has been followed by others. It is probable that New York will, within a reasonable time, work out some feasible plan for the proper disposal of its sewage instead of discharging it into the harbor waters without proper purification. The Metropolitan Sewerage Commission has already taken a strong position against such a course.

Under the head of "Condition of water in main channels"
2294 (p. 43) the Commission says: "Not only does the discharge of sewage now produce objectionable conditions near the points of outfall, but the water which flows in the main channels of the harbor above the Narrows and in the East and Hudson rivers is more polluted than considerations of public health and welfare should allow." I am quoting now from their exact language.

Mr. Riker: The same objection to this quotation from the Metropolitan Sewerage Commission's report. This has to do with the pollution of the harbor by New York and has nothing to do with the interests of this case and is therefore immaterial and irrelevant.

The Commissioner: Note the objection of counsel for defendants.

Q. Proceed Mr. Fitz Gerald.

A. "The studies made by this Commission show that the digestive capacity of this water for sewage is so reduced by pollution that restrictions should at once by placed upon the discharge of sewage therein to prevent the harbor from becoming positively offensive. It has been proved that, contrary to popular belief, the tidal currents do not flush out the harbor satisfactorily, but cause the sewage to oscillate back and forth near its point of origin."

I am of the opinion that New York has gone to this trouble and expense if she has no intention of undertaking sincerely to carry out the best available course to protect her harbor waters and her vast commercial interests from the evil effects of sewage pollution. It is absurd to suppose for a moment that her attitude is assumed for political or any other reasons than a desire to take some sensible step, before the nuisance of harbor pollution becomes unbearable. In this respect she has the lesson to read of the older civilizations, where Harbor and Conservancy Boards have been the result of expe-

rience. In other words it will not do for New York to keep
2295 on pouring her load of crude sewage into the Bay much longer. While preparing her plans for a general cleaning up, it seems a particularly trying moment for a sister state whom she has already invited to join in some general and comprehensive plan, to answer by dumping a very large proportion of the total sewage load into the harbor. New York has the ample experience of other communities from which to judge that, if New Jersey is once allowed to invest in this expensive construction of intercepting sewers terminating in a pumping station capable of raising 400,000,000 gallons of sewage daily to a sufficient height to send it out through a tunnel under Bayonne and the Upper Bay and discharging it at Robbins Reef, that no process of law will ever be raised to prevent this discharge in the future, whatever the results may be.

Mr. O'Sullivan: Your witness.

Cross-examination.

By Mr. Riker:

Q. You are under retainer by the State of New York in this litigation?

A. Yes.

Q. And are being paid for your services, of course?

A. Yes.

Q. How long have you been under such retainer from the Complainants in this case?

A. From the complainants?

Q. Yes.

A. Well, I think more than a year. How much more than that I cannot quite recall.

Q. Your connection with the investigation has been in consequence of your retainer, has it not?

A. Not wholly.

Q. Now, as I remember it, you said you had some connection with the Chicago Drainage system?

A. Yes.

Q. You were associated with that for six months?

A. Yes.

2296 Q. In what capacity?

A. I was employed under the provisions of the act to make a report upon the hydraulics and the conditions of the act, before the sewage could be let into the canal.

Q. Was that a part of the litigation between Missouri and Illinois?

A. No.

Q. In that connection you got some acquaintance with the tunnel construction and in the operation of that system, did you?

A. Yes.

Q. Is there any purification of the sewage in that case?

A. It is a process of dilution simply.

Q. And the canal discharges where?

A. The canal discharges into the Desplanes River.

Q. Is Chicago a riparian city on the Desplanes River?

A. I should think it was.

Q. Was it before the Drainage Canal was constructed?

A. It is a difficult question to answer, because the outlying portions of Chicago extend so far, and I do not know that I can answer that.

Q. What are the limits, in your judgment, of a distance within which a territory can be said to be riparian to any particular body of water?

A. I should think that any town or city which was actually situated upon the banks of a river or a great tidal estuary was truly riparian. I should consider that if that town or city were situated miles inland that it was not.

Q. I understand that, what is then the distance to which a community would be riparian in your judgment, would depend on the artificial municipal limits established by the legislative act incorporating the municipality, would it?

A. I think not. I think it would depend more upon the natural physical characteristics made by Nature in the way of topography.

2297 Q. And in connection with the construction of drainage and sewerage, what in your judgment is the territory that is riparian to any body of water?

A. I should think that the sewers of the towns or cities or communities which are described as being situated on the banks of a river or a great tidal estuary or lake would be considered riparian sewers.

Q. And the fact that there happens to be an artificial boundary between a county and a small municipality would determine the extent of the territory without reference to the municipal governments which would be properly riparian?

A. No.

Q. What do you mean?

A. I considered, as I stated before, it is more the natural topographical conditions.

Q. Is it not, in other words, merely a question of drainage area?

A. No, not at all.

Q. Have you had occasion to examine the territory which you have spoken of as Orange, East Orange, Bloomfield, Glen Ridge and Montclair?

A. Only in a most casual way.

Q. Are they riparian to the Passaic Valley or not?

A. I am not able to answer that definitely, but I think not.

Q. So, they not being riparian?

A. One moment, let me consider. I would like to have a map. I——

Q. I am asking your recollection, if you do not remember, of course, you can say so?

A. Well, I say so, I do not remember.

Q. You do not think, under your definition of the properties of

drainage that those municipalities should drain into the Passaic River?

A. I said I could not remember.

Q. Well, if they are not riparian they should not drain into the Passaic River.

A. Well, if by so doing they would create a damage to the other communities I should say not.

2298 Q. Then it becomes purely a *whether* of whether or not the drainage creates a nuisance which has injurious effects on other municipalities?

A. Not wholly. It has got a good deal to do with it.

Q. What is it that determines whether they should or should not discharge sewage into any particular body of water?

A. I think the consent of the true riparian owners has a great deal to do with it.

Q. And these schemes of Mr. Gray and Mr. Allen Hazen for the disposal of the sewage of the city of Paterson, they involve the location of the disposal works towards the Hackensack, did they?

A. I think so.

Q. Is that in the natural drainage area of the riparian territory of the city of Paterson?

A. No.

Q. That is an entirely different water shed?

A. Yes.

Q. On the Hackensack water shed?

A. Yes.

Q. And the point where they were proposing to locate the disposal works was in a different county, was it not?

A. I think so.

Q. And do you think that is a proper exercise of municipal power, do you?

A. I do.

Q. You are familiar with the Metropolitan Sewerage District and the drainage and the water system of Boston?

A. Somewhat.

Q. What riparian territory do those sewers serve in the way of drainage?

A. I think pretty generally riparian properties.

Q. On the Boston Bay?

A. Not on the bay, no, not in that sense.

Q. What do they serve?

A. They serve communities either on the bay or situated on an estuary entering into the bay.

Q. You mean by that rivers?

A. Yes.

Q. And in the same sense in which the proposed Passaic Valley sewerage system is to serve the municipalities on the Passaic

2299 River?

A. No.

Q. In what way does it differ?

A. Because here the interests which are to be affected by this discharge are very different from what they are in Boston Harbor.

Q. But I am talking of the territories themselves?

A. The topographical conditions?

Q. Yes.

A. Yes.

Q. They are very similar, are they not?

A. Similar but only in degree, because the Passaic River enters into a large bay.

Q. You mean similar in kind but different in degree, don't you?

A. Yes, exactly.

Q. And that system was devised and adopted and put into operation in order to cure local conditions which are very similar to those that extend along the Passaic River?

A. Similar but different degrees.

Q. The qualifying superlative "very" should be left out, make it similar. The streams that are estuaries to Boston Bay were polluted by sewage before that system was put in operation, were they not?

A. They were, but that was not the principal factor in the case.

Q. And the shores of the bay about the city of Boston were also polluted as the shores of the city of New York are polluted?

A. Yes, quite.

Q. And it was on account of that in part that the system was adopted?

A. Yes.

Q. So that, as a matter of fact, the Passaic Valley sewerage system in kind is similar to the Metropolitan District Sewer.

A. I think it is quite dissimilar in a great many points and I think the most vital and important of all is the fact that here in New York, in connection with the Passaic Valley plan or scheme, the sewage is to be discharged at a point where it can do serious injury to important interests of the large cities all around
2300 it, while in Boston the sewage was to be discharged in an open tidal estuary where there were no important commercial interests, and where the rise and fall of the tide is more than double.

Q. I was not speaking of the practical result of it. I was speaking now particularly of the purpose of it, and whether as a matter of fact, the purpose of it is not to apply to similar conditions a similar solution?

A. I have already answered that question.

Q. Now, are you aware, Mr. Fitz Gerald, that the point of the proposed discharge of the Passaic Valley district sewer is within the jurisdiction and sovereignty of the State of New Jersey?

A. Perfectly, to a certain extent.

Q. Why do you limit it to a certain extent?

A. Because there are other authorities which have an interest in it.

Q. The point of discharge?

A. Certainly.

Q. What other parties are there that can be interested?

A. The Government has already made an arrangement by the stipulation. Then, I think there are other considerations such as police powers which have been arranged for.

Q. That is a legal question which you think may have some effect on it, but which you do not profess to be competent to determine?

A. Yes.

Q. But you do know that the actual points of discharge are within the territorial district of the state of New Jersey?

A. Yes.

Q. And large parts of the waters of the bay, so called of New York, are within the territorial limits of the State of New Jersey?

A. A very considerable portion.

Q. Now, you have made some personal examinations of the conditions which existed in 1911 in the waters of the bay of New York. Those were all made during the summer and autumn of 1911?

A. Yes.

2301 Q. And during hot weather?

A. Yes. Pardon me a moment, with the one exception I think.

Q. That was the one made in October?

A. Yes.

Q. Was not that made in New Jersey?

A. Not wholly, no. There was one made along the East River.

Q. The Harlem and the East River?

A. Yes.

Q. And where did you find the waters of the harbor of New York seriously polluted?

A. Where?

Q. Yes?

A. All along the Manhattan front, the Hudson River, the Harlem River, the East River, the Brooklyn front.

Q. Gravesend Bay?

A. Well, I was coming to that, pardon me.

Q. Jamaica Bay?

A. Jamaica Bay, Newark Bay.

Q. You do not call New York Bay part of the waters of New York Harbor, do you?

A. Certainly.

Q. You consider that part of the harbor?

A. Certainly.

Q. You do not call it a part of New York Bay, though?

A. Oh, no.

Q. Now, finding the waters of the New York Bay polluted in different places which you have described, did you trace the source of pollution?

A. Not the sources, no.

Q. Well, did you endeavor to discover what municipalities were responsible for the pollution?

A. Why, in a general way I was cognizant of that.

Q. What were they?

A. For instance, all along the Manhattan shore the sewers which drain are sewers under the control of the city of New York. When you come to the Bronx, and when you come to Queens, and when you come to Richmond, they are sewers built under the administration of the different sections now comprised in the whole Metropolitan District.

Q. And part of the greater city of New York.

A. Yes.

Q. And all within the sovereignty of the State of New York, the complainant in this suit?

A. No, with the exception of those on the Jersey shore,

2302 yes.

Q. Did you make a special investigation of those on the Jersey shore of the New York Bay?

A. Yes.

Q. You have not described it in your direct testimony?

A. No. Those were principally made in connection with the chemical analyses, and with the oxygen analyses.

Q. Furnished you?

A. By the commission.

Q. I intended to ask you whether you made any personal examination of the pollution along the Jersey shore?

A. Some; they might be called of a commercial nature.

Q. Not connected with the retainer?

A. Yes. To see if commercial interests were affected.

Q. The commercial interests of the State of New Jersey?

A. In New Jersey.

Q. In New Jersey?

A. Yes.

Q. Now, in your opinion, does the pollution of the waters of New York Bay by the discharge of sewage into it from the cities of the State of New York create a nuisance which affects injuriously the property within the State of New Jersey?

A. I think so.

Q. You think so?

A. Yes.

Q. Is or is not the polluting power of a sewer discharge dependent upon the actual population the sewers serve which are discharged into the waters?

A. In degree, yes.

Q. Does the character of the population to be served by that Passaic Valley sewer differ materially from that served by the direct discharge of sewers from the city of New York into the harbors of New York, the bay of New York?

A. I have not had an opportunity to make as thorough a study as I should have desired of that, but my impression is from what I saw that the character of the Passaic Valley sewage will be decidedly different from that now floating into New York Harbor from the riparian proprietors.

2303 Q. In what respect?

A. I think this sewage coming such a long distance, being detained on its way will be in a very much worse condition for absorbing oxygen from the waters than the fresh sewage which comes out of the sewers of New York and Brooklyn and other riparian cities. I think that that sewage will contain—I am not quite sure of this—but possibly a larger percentage of trade wastes.

Q. In your judgment the trade wastes are more absorbent of oxygen from the waters than crude sewage?

A. No, I should not say so, but the trade waste produces a very nasty effect.

Q. Confining your attention then to the dilution of oxygen in the waters of New York Bay, is it your opinion that the discharge from the Passaic Valley sewage will be more injurious per capita of inhabitants served by it than the discharge from the sewers within the State of New York?

A. That is my impression.

Q. Is that based upon the fact that you think there will be more trade wastes in the New Jersey discharge?

A. It is based on that fact, and also due to the long distance that the sewage has to come.

Q. Then you do think that trade wastes are more absorbent of dissolved oxygen than ordinary sewage?

A. No, it does not follow.

Q. You have testified to an examination of Newark Bay and the Passaic River, a personal examination?

A. Yes.

Q. And the taking of samples?

A. Yes.

Q. Did you analyse those samples?

A. No.

Q. They were simply for inspection?

A. Simply for inspection.

Q. I think you said you found the Passaic River, either on that inspection or from other data submitted to you, to be practically an open sewer?

A. Yes.

Q. And the oxygen in the water of the river has practically

2304 disappeared?

A. I think it was worse than an open sewer, I think I stated so.

Q. And as to oxygen?

A. Yes.

Q. And to what point does that condition extend down the river towards Newark Bay?

A. It is difficult to define that.

Q. You have not examined it with a view to determining it?

A. No, I should say the lower portion of the river.

Q. Does that mean where it joins the bay?

A. Yes.

Q. How long is the bay?

A. The bay I think is about——

Q. You gave the figures in your direct testimony. I did not know but what you would remember it.

A. I gave so many figures it is difficult for me to remember, but I have it here.

(Witness examines memorandum).

A. Witness (continuing:) I had a table here somewhere of those sizes. I see I have only the area, 8.35 square miles.

Q. You have not the length of it?

A. I think I gave it, I think it is 4½ miles.

Q. Without refreshing your memory you cannot state, but you think it is about 4½ miles?

A. Yes.

Q. And the width thereof?

A. Well, I cannot remember it. Looking at the bay it ought to be about a mile and three quarters wide.

Q. This open sewer of the Passaic River is in a very bad state as I understood, worse than an open sewer?

A. Yes.

Q. Becuase of the extreme advance of putrefaction?

A. Yes, its avidity for oxygen.

Q. Now you have observed the determinations of dissolved oxygen as they purport to be established by exhibits in this case at the lower end of this bay?

A. Yes.

Q. Do you remember what that was?

A. Perfectly.

Q. What was it?

A. 64%.

Q. And you remember from the same alleged authority what the dissolved oxygen was at the lower end of the Hudson River at its mouth?

A. Perfectly.

2305 Q. What was that?

A. 55%.

Q. And the East River, do you remember that?

A. Perfectly.

Q. What?

A. From 50 to 55 per cent.

Q. Nearly 10 per cent less than at the Lower end of Newark Bay?

A. Yes, 20 per cent.

Q. The population to be served by the Passaic Valley sewer discharges its sewage into the Passaic River, now, and when you observed it?

A. Yes.

Q. How do you account for the disappearance of the pollution to the extent that it seems to have disappeared in the distance of 2½ miles in a shallow basin like Newark Bay, as you have described it?

A. I think Newark Bay is very remarkably situated for doing that work on account of its extent, and that no other sewers empty

into it on the immediate lines of the bay, the immediate banks. And that this sewage has to go the whole length of the bay and that it is a large shallow body of water which gets stirred up a great deal all the way through its depth and the depletion in oxygen is only slightly greater than it is in the other two points that you have mentioned.

Q. The depletion is 10 per cent less.

A. More than that; nearly 20 per cent I think.

Q. About 10 per cent?

A. About 20 per cent.

Q. 20 per cent difference?

A. Yes.

Q. And the depletion in Newark Bay is less than at the other two points I drew your attention to about 20 per cent?

A. Yes, about 20 per cent, yes.

Q. Are you aware that the Hackensack River is also a carrier of sewage matter?

A. I had an idea that the Hackensack River was not very seriously polluted.

Q. You know it discharges into Newark Bay?

A. Perfectly, yes.

Q. Now, the sewage digestive power of a body of water is determined by the amount of dissolved oxygen, is it not?

2306 A. That is one of the measures, I think that is one of the important measures.

Q. What else is there that helps to digest and dispose of sewage in water except the dissolved oxygen?

A. Well, the dissolved oxygen is certainly an excellent measure, but there are many other operations of Nature which aid, in connection with the dissolved oxygen.

Q. In your study of the waters of New York Bay and of the harbor generally, you have placed great importance upon the question of dissolved oxygen?

A. Yes.

Q. And that is practically the only disposing or digestive agent that you have considered, is it not?

A. It is the principal one.

Q. What other one have you considered in your examination?

A. Well, I have devoted some thought to the operation of forms of life.

Q. Such as what?

A. Such as infusoria algæ and animal life, forms of animal life.

Q. Have you attempted to determine what the amount of influence is on the digestive power of the waters of New York Harbor, what the per cent. is by these particular forms of life?

A. No, I have not attempted to measure it.

Q. Newark Bay is shallow water is it not?

A. Yes.

Q. For the most part very shallow?

A. I should say it is.

Q. And is the mean temperature of water increased or decreased by the fact that it is shallow?

A. Up to a certain depth I should say there was not any difference.

Q. No difference?

A. No.

Q. What is that depth?

A. Well, I have generally found it to be from my own experience a depth of about 25 feet, a body of water of about that size.

Q. You think from your observations of it that a body of
2307 water of the depth of New York bay at Robbins Reef, say 40 or 50 feet will be the same in temperature for the first 25 feet in depth as the waters of Newark Bay?

A. I should expect to find the waters of Newark Bay somewhat warmer.

Q. And therefore less capable of retaining oxygen?

A. Yes.

Q. So that in that respect the waters of Newark Bay are relatively as able to digest sewage matter as the deeper waters of New York Bay?

A. Yes.

Q. Now, where then does the water of Newark Bay obtain the digestive power which enables it to destroy the pollution of the sewers that drain into the Passaic River in a distance of 4½ miles by a width of nearly two miles, so that the percentage of oxygen is 20 per cent higher there than it is at the mouth of the Hudson River or the East River?

A. I do not consider that the effect is destroyed. I consider that the putrefactive changes are not completed by the time they reach the lower end of the bay. I simply consider that starting from the upper end of the bay with a very low percentage of oxygen in the water, after reaching the lower end of the bay, it has been increased, that percentage has been increased. That the oxygen is still being taken from the water because the processes of putrefaction are not completed.

Q. Now, taking that same sewage after discharging it at Robbins Reef at a depth of 40 feet, at a less advanced stage of decomposition or putrefaction, and therefore with less avidity for oxygen, do you think that sewage discharged at that point, what effect will it have on the waters of New York Bay, how far will it be perceptible?

A. I think that will be very detrimental and that——

Q. Tell me in figures, if you can, what effect you anticipate?

A. I anticipate that that sewage will in a short time rise to the surface. I anticipate the discharge as it is only over a comparitively limited area and a continuous discharge of a very large mass of sewage, amounting, as I have shown to a sufficient quantity
2308 to cover a great many hundred acres, that it will be perceptible in a great many ways, and that it will form a sewage field, a large sewage field, which will be blown by the winds and taken by the tides to all the adjoining shores.

Q. Not being a scientific gentlemen I, of course, evidently do not

limit myself sufficiently. I will try to do so now. To what points with reference to the actual places of discharge with the discharge of an equal amount of sewage to that which is now being discharged into Newark Bay, if discharged at Robbins Reef, to what point will it be perceptible in the reduction of dissolved oxygen in the waters of New York Bay, assuming now that the waters are not polluted by the state of New York or any of its municipalities?

A. I do not know that I can answer that question, Mr. Riker. I should like to. I do not think I am capable of answering it.

Q. Cannot you approximate it?

A. I do not think it is possible to say definitely.

Q. Would it be perceived to the extent of reducing the oxygen to 64% for more than 4½ miles from the point of discharge?

A. I think there is no doubt but what that sewage will be in such condition that its avidity for oxygen will be extraordinary and very much worse than a fresh sewage, and that it will lower the dissolved oxygen in the waters all around the harbor of New York, all around the shores of New York Harbor.

Q. I was endeavoring to direct your attention to the same amount of sewage that is now being discharged into Newark Bay if it were discharged at Robbins Reef. What effect do you say that will have on the free oxygen in the waters of New York Bay and how far it will be perceptible from the point of discharge *is* the reduction of the free or dissolved oxygen in the waters of New York Bay?

A. I think it will be perceptible to a great distance. Exactly what that distance will be it is impossible to state.

Q. It would be a mere guess, would it not?

A. No.

2309 Q. Then why cannot you state it?

A. Because I think an expert can form an idea of the distance to which it will be perceptible which is extremely different from a mere guess.

Q. Now, Mr. FitzGerald, taking your figures based upon these reports of determinations of free oxygen at the mouths of the Hudson and East Rivers, I understand you to say that from your examination of this data that has been submitted to you, which figures represent the average oxygen content at those points?

A. By no means.

Q. What do they represent, then, those figures, if they do not represent that?

A. Those figures represent the average condition of dissolved oxygen in those waters in these sections across the rivers during the summer season.

Q. I should have limited it, evidently, to the time that they were taken. You think they represent an average of the waters at those points at the time they were taken?

A. Yes, a fair average.

Q. As a matter of fact do they represent anything except the average of those samples which were actually taken?

A. I think they do.

Q. What?

A. Because I think it is a fair inference if you have——

Q. I did not ask you for your reasons, I asked you what they represent.

A. They represent to my mind the average condition of the dissolved oxygen in those sections at every point of the section, by inference. The observations are taken at intervals and if you have a very uniform result in these different intervals it is a very fair assumption, and one universally adopted in the profession, to consider that the intermediate areas are represented by similar figures.

Q. If it be a fact, in other words, that the samples are taken so as to be a fair representation of the whole water, can the average give a fair average of the whole?

A. Yes.

2310 Q. That is all you mean? Now, can you say they were so taken?

A. It is my belief that they were so taken.

Q. Have you investigated to find out whether they were so taken?

A. Yes.

Q. Now, at what distances were they taken apart. I want you to direct your attention first to the North or Hudson River determinations at its mouth?

A. At the North River, you mean the Hudson River?

Q. We call it the North River usually here.

A. Those observations were taken in vertical lines from at the surface, 20 feet down, and 40 feet down, 35 feet in some cases. They were taken generally at some point off of Pier A about 100 feet from Peir A. Then they were taken a quarter way across. Then at midstream; then three-quarters of the way across, and then at a point on the Jersey coast about the same distance from the pierhead as on the New York side.

Q. So that from the horizontal plane they were taken at about equal distances?

A. I should think so.

Q. And vertically they were taken?

A. At the surface, at 20 feet, and at 40 feet.

Q. Is that true of the observations taken on the Jersey side?

A. Yes.

Q. They were taken at a depth of 45 feet?

A. I did not say 45 feet.

Q. 40 feet?

A. Yes.

Q. Within 100 feet of the pier?

A. 28 feet, generally at a depth of 28 feet for the deepest part and 25 feet in some cases but also at the 20 foot distance.

Q. The object of the sampling is to take a fair sample of the whole body of the water?

A. I should think that was evidently the intention.

Q. Do you think that was accomplished?

A. I think so.

Q. Now, at a distance of 100 feet from Pier A, at a depth
2311 of 1 foot, is or is not, was or was not its water, or were not the samples taken in the sewage field caused by the sewers from Manhattan Island, in your opinion?

A. They were taken, in my opinion, within the influence of the sewage field. That is to say, I think all of those sections, were, all of those observations, because I found that at a distance of two or three hundred feet from the pierheads there were in many cases no appearances of the field, but always the scum. It could always be detected.

Q. Have not you testified that at this particular place, Pier A, was a well defined sewage field when you observed it?

A. I do not think so.

Q. You do not remember. You never observed a well defined sewage field at this point?

A. I do not think I testified to that.

Q. You never did observe any?

A. I do not remember observing it.

Q. To what depth do sewage fields extend in your observation about New York?

A. I do not know.

Q. You never made any investigation of that?

A. I have made some observations, and they extend in my opinion from the bottom, following a curved line. As the sewage passes out it gets thinner and thinner, so that after travelling some distance it gradually becames attenuated, so that it is only a few inches thick.

Q. From the bottom?

A. From where it starts.

Q. You are assuming now that the sewer discharges directly into a slip?

A. Yes.

Q. Do not you know that a good many of the sewers in New York discharge from a pierhead?

A. Yes, I have seen them.

Q. In those cases?

A. The same things have taken place there.

Q. What do you refer to?

A. I think where they discharge at a pierhead, that the sewage field is quite deep below the surface, but it very soon begins
2312 to work up.

Q. You know that these sewers discharge at the surface either at high or low tide, do you not?

A. At all stages of the tide; to all stages of the tide.

Q. You know that they discharge at the surface of the water either at low or high tide?

A. They discharge at all stages of the tide.

Q. Don't you know that none of those sewers discharge at any time below low water surface?

A. Yes.

Q. Where are there any that discharge below low water?

Q. Below low water?

Q. Yes.

A. I do not recall any that discharge below low water.

Q. Now, you have said that sewage matter is lighter than the waters of the bay?

A. Yes.

Q. Now, if that is so, at the discharge point from those sewers, which are no lower than low water, we will say that, the surface of low water?

A. Yes.

Q. How, at that point do you get a sewage field extending down to the bottom?

A. Because the heavy particles in the sewage are being all the time thrown down and if you go, as I have frequently, around the edges of these fields, you will find that when they first come out the action is very strong in sending the material down to the bottom.

Q. How far off from the shore does this force extend, may I ask which forms a sewage field of that character?

A. I cannot say.

Q. Cannot you give a limit?

A. No, because I think it depends so much on the current and the state of the wind, I doubt very much if it is possible to define it in actual terms of measurement.

Q. Do not your oxygen determinations, as they have been pointed out to you, indicate where the limits of the sewage field about
2313 the City of New York are located?

A. No.

Q. They are not indicated at all?

A. Where there is a very marked drop in the percentage of oxygen I think it generally indicates it is in a sewage field, a mass of water like that which you are inquiring about at the mouth of the Hudson River, it has been very much churned up by a great many different causes, and it is a very different question there. The cross-section is very much more uniformily affected by the sewage discharged.

Q. That is just what I am coming to. You take your data upon which you have formed your average. Read the data so that we may see what the limits are upon which your average is formed?

A. Certainly, these are my own notes.

(Witness examines memorandum).

Q. They are based on the exhibits?

A. They are based on the exhibits, yes. On August 10, this one that I now have before me, 1911, the tide was ebb. The first observation was taken 100 feet off from Pier A. The percentage of dissolved oxygen was represented by .54 at one foot below the surface; at 20 feet down it is represented by the figure .56 and 40 feet below the surface it is represented by 58%. The next observations were taken one-quarter way across and there the percentages were 55 one foot below the surface, 58 20 feet below; 58 40 feet below the surface.

Q. That was a quarter way across. Do you know how far that is from the first station.

A. Yes.

Q. About how far?

A. About 1000 feet I should think.

Q. The next station.

A. The next station was in mid-stream and there the dissolved oxygen was represented in percentage by the figure 56 1 foot below the surface; by the figure 59% 20 feet below the surface and by the figure 59% 40 feet below the surface.

Q. The next station.

A. The next station is 100 feet off the Central Railroad of New Jersey and is represented by 55% one foot below the surface; 57% 20 feet below the surface; 57% 28 feet below the surface.

2314 Q. And upon that you made your average of 54, did you?

A. No.

Q. The average extends over a number of observations?

A. A great many, yes.

Q. Just confining your attention to those observations, how do you explain the fact that the percentage within 100 feet of Pier A is as high as it is, in view of the fact that it is within the area of the discharge of crude sewage by the sewers of the Island of Manhattan?

A. I do not think it is high. I think that the effect is very marked, and I think that the loss of one-half of the dissolved oxygen in the waters there at that point is due to the sewage discharges which are carried by the winds and the currents and constantly passing boats up and down, and the tides ebbing and flowing constantly. If you studied these waters as I have you would become very much impressed with the fact that this backward and forward movement all the time causes a very thorough mixing.

Q. Perhaps I should have been a little more exact. How do you account for the percentage being so high at that point compared with the percentage in the middle of the cross-section.

A. I think there is very little difference. I think it is very remarkable that there is so little difference.

Q. Have you no explanation as to why that should be so?

A. Yes.

Q. What is it?

A. The flow of the Hudson River in the summer season was so low that the effect of the sewage discharges is to make a very uniform section.

Q. And the uniformity of the effect in the way of pollution by the causes operating is practically uniform all the way over to within 100 feet off the pierhead of the Central Railroad of New Jersey?

A. I judge it to be so at the time these observations were made.

Q. And how far is that, if you know, from Pier A?

2315 A. It is about one mile across.

Q. Is that all; that is all?

A. That is what I have in mind. I would not testify to it without looking it up carefully.

Q. So that, in your judgment, the discharge of crude sewage from

the sewers of Manhattan Island has resulted, or did result at that particular time, in a perfectly uniform deterioration of the waters of New York Bay, extending way over to the New Jersey Shore?

A. No.

Q. Why not?

A. Decidedly not.

Q. Well, what was at that time the chief source of pollution of the waters of New York Bay?

A. Well, it is difficult to say what the chief cause was. Of course, as I have stated before the Upper Bay is a great mixing basin and all these sewage discharges, they pass up and down under the influence of the tides and the wind, and moving long distances north of any point we have mentioned.

Q. Do you think that the water below that point, where the oxygen at this time was about 70% or so, do you think that may have resulted in producing 54 or 55 or 56 percent. of oxygen at the point of the cross-section?

A. Why, I think very probably that affected it favorably.

Q. You think it raised it?

A. Yes.

Q. Then the mixing basin was not efficient in producing its low oxygen content?

A. The mixing basin, as I have stated is effective, not only on the discharge of the Hudson River and the East River, and the discharge of the Lower Bay through the Narrows, developing a pure revivifying effect, that is, comparatively pure ocean water that comes in. If it were not for that dissolved oxygen, it would be in my opinion very much lower.

Q. So that, instead of the mixing basin affecting the dissolved oxygen by reaching it, as a matter of fact, in your judgment, it affects it by increasing it?

A. Keeping it higher, yes.

2316 Q. Now, what in your judgment was the chief source of the influence that was reducing the oxygen at that cross-section at the period of these determinations?

A. I think the chief cause was the sewage discharges.

Q. From where?

A. Well, around that neighborhood.

Q. From what municipality chiefly?

A. Well, New York chiefly, I think. I think New Jersey, contributed, not to the same degree.

Q. Sewage pollution bears a fair relation does it not, to population?

A. Yes, proportion of population.

Q. And where is the great population that is sewering into those waters?

A. The great mass of population is distributed over a large area of the shore, but I should say it was decidedly in New York, and Brooklyn.

Adjourned to June 20, 1912, at 10.30.

2317 Supreme Court of the United States, October Term, 1911.

The People of the State of New York, Complainants,
against
State of New Jersey and Passaic Valley Sewerage Commissioners, Defendants.

Corporation Counsel's Office,
New York City, June 20, 1912—10:30 a. m.

Present: James D. Maher, Esq., Commissioner.

Appearances:

Dr. William J. O'Sullivan, Special Counsel for the People of the State of New York, Complainants.
Adrain Riker, Esq., of Counsel for the Passaic Valley Sewerage Commissioners, Defendants.

Met pursuant to adjournment.

Desmond Fitzgerald, a witness called on behalf of the Complainants, recalled for further cross-examination, testified as follows:

Cross-examination by Mr. Riker (resumed):

Q. Did you make any determinations of the averages of dissolved oxygen at Mt. St. Vincent cross-section?
A. Yes, I examined that carefully and copied those notes myself.
Q. You took the figures, I suppose, from the exhibits in the case?
A. Yes.

Q. Now, have you your notes so that you can turn to that,
2318 to those observations?
A. Yes.

(Witness examines notes.)

Q. You are familiar with the localities, from actual observations, are you?
A. I do not think I am familiar with it now. I have simply been there in a boat.
Q. The west shore of the river at that point, what is there there if you remember?
A. On the west shore?
Q. Yes, the point where that cross-section starts?
A. The Palisades, you mean?
Q. The Palisades?
A. Yes.
Q. Is there any sewage discharge at that point, so far as you know, on the west side?
A. On the west side, no.
Q. And on the east side, does the cross-section line strike the central part of the city of New York, the thickly populated part?

A. I should not think the thickly settled part.

Q. It is about that, and now will you take one of the series of observations, determination, and give me the determinations as they were before you at the different stations, at different depths? The date of the observation that you used?

A. The first one that I have taken was on October 13, 1911. The first point in the cross-section was 500 feet off Mt. St. Vincent. Flood tide. The dissolved oxygen was taken one foot below the surface, 20 feet below the surface and 40 feet below the surface. The observation one foot below the surface showed a percentage of dissolved oxygen of 84. At 20 feet below the surface it showed 78 per cent., and at 40 feet, 78 per cent. One-quarter way across it showed 85 per cent. at the surface and 79 per cent. 20 feet below and 79 per cent. 40 feet below. One-half way across, 86 per cent. at the surface; 83 per cent. 20 feet below; and 84 per cent. 35 feet below. Three-quarters way across, 88 per cent. near the surface; 84 per cent. 10 feet down; 84 per cent. 20 feet down. 500 feet off
2319 west shore, 87 per cent. at the surface; 83 per cent. 10 feet down; 83 per cent. 15 feet down.

Q. Now, taking those observations, can you determine in a rough way from what sewer the pollution was affecting the oxygen?

A. No.

Q. You would not be able to even venture a supposition on that subject?

A. I might by a long study and consideration form some idea, but I cannot now.

Q. You would not be willing to venture an opinion on it?

A. No.

Q. Now, how far above the mouth of the Hudson River, of the cross-section which we were inquiring about yesterday afternoon is this cross-section?

A. A long distance.

Q. About how long a distance?

A. I should think it is ten or twelve miles.

Q. Now, in the ten or twelve miles below the Mt. St. Vincent cross-section and the mouth of the Hudson cross section the sewage from how many inhabitants or human beings is poured into the Hudson River, if you know?

A. It is difficult for me to form a judgment of that, because the Island of Manhattan is such a narrow one, and the drainage takes place in both directions, through the Harlem and through the Hudson and I would like to study that question before answering it.

Q. Would you not be able to answer that question without further study?

A. No.

Q. Can you answer without further study approximately the proportion between the State of New Jersey, the proportion between that discharged by the State of New Jersey and that from the State of New York in that district?

A. No, I never considered it.

Q. Well, between the Mt. St. Vincent cross-section and the mouth

of the Hudson cross-section the free oxygen, or dissolved
2320 oxygen, in the water appears to have been materially decreased and diminished in the observations in 1911, does it not?

A. Yes.

Q. To what do you attribute that diminution?

A. I attribute it to the discharge of organic matter, putrescible organic matter.

Q. From where?

A. From around the margins of the harbor.

Q. Chiefly from the city of New York?

A. A great deal of it there, yes.

Q. Chiefly, I said?

A. Yes.

Q. Now, will you take your cross-section, if you have it, at Robbins Reef. The cross-section observations if you have those.

A. I am sorry to take so much of the time, but I find these are somewhat scattered, but I can give you, I think, probably what you want, the most important of them, at once. On October 16——

Q. That corresponds very nearly with the Mt. St. Vincent series?

A. Yes. I have an observation one half a mile northeast of the reef. Three samples gave 64 and 65 as the percentage of dissolved oxygen.

Q. Three samples at different places, you mean?

A. I presume they were; I do not now recall.

Q. On the same day at another station?

A. On the same day I have another one-half a mile east, southeast, which gave 64 and 68. I have another nine samples, flood tide, one-half mile south, 64 and 65. I have another on this same date one-half mile northeast, that gave 65. I have another one-half a mile east, southeast, which is marked three samples. I presume it is for the average of three samples. It gives 66. I have another one-half mile south which gave 66, 67 and 67, and I presume those to be different places. I have another one-half a mile
northeast again still, on flood tide, which gave 67, 77 and
2321 77. I have another one-half mile southeast. Those were I know at a depth of one foot, 20 feet and 40 feet, 67 per cent., 73 per cent., and 73 per cent. I have another one-half mile south which gave 71 per cent., 76 per cent., and 76 per cent., and those were taken at depths of one foot, 25 feet and 50 feet.

Q. Have you the determination of the average at this location before you?

A. As I remember it the average was about 73.

Q. And you remember the average on the figures that were submitted at Mt. St. Vincent cross-section?

A. I think it was 84, I am not sure about that, without looking.

(Witness examines notes.)

Q. (Continuing.) I think probably I have overstated it, Mr. Riker.

Q. I show you Complainants' Exhibit No. 133 and draw your at-

tention to the Mt. St. Vincent cross section. Does that correspond with your determination?

A. That corresponds with my remembrance of it.

Q. 78?

A. Yes.

Q. And the average at Robbins Reef, does that also correspond with your recollection?

(Witness examines exhibit.)

A. Yes.

Q. Will you state them?

A. 72 per cent., 74 per cent., and 78 per cent.

Q. Those are at different stations about the Reef?

A. No, I think those are the averages the different days.

Q. Of the samples taken at different points about the Reef, as you understand it?

A. Yes.

Q. And that is not a cross-section?

A. It is a section as I remember it, taken in a circular
2322 way around the Reef so as to show the nature of the water.

Q. A circular area about the proposed location of the outlet?

A. Yes. I think it was my suggestion.

Q. Now, Mr. Fitz Gerald, in the East River the cross-section at the mouth of the East River appears here to be 54 per cent.?

A. That is as I remember it.

Q. And as I read it the cross-section at Hell Gate, I think it is 57?

A. I remember it so.

Q. And at the mouth, at the entrance to Long Island Sound, it is 85?

A. Yes, as I remember it.

Q. Having those figures before you as indicated on this chart, to what do you attribute the difference in dissolved oxygen about the Island of Manhattan in the East River and the Hudson River?

A. I have not attempted in my analysis to attribute them to any particular cause except the discharge of organic, putrescible organic matter into the waters which come in contact, which are found at those parts.

Q. And in the case of the East River, that organic matter, so far as you know, discharged directly from the city of New York into the East River and into the Harlem River and the Gowanus Canal?

A. Yes.

Q. Or Newtown Creek?

A. Yes.

Q. Now, the sphere of influence of that discharge in the East River, as indicated by the determinations there, seems to be limited to the mouth of the East River at New York Bay, and its other mouth, where it enters Long Island Sound?

A. I do not know that I understand the question.

Q. You do not find any indications of the influence of the dis-

charge into the East River beyond those points, so far as these determinations show, do you?

A. Any influence of sewage discharges?

Q. Yes.

2323 A. In to any other part of the harbor, you mean?

Q. No, the influences of the discharges into the East River are not apparent on this chart beyond those points that I have directed your attention to.

A. You mean simply those three sections?

Q. Yes.

A. I did not catch your idea. I have other determinations of dissolved oxygen than those represented on this chart.

Q. Taking those on that chart it appears not to be perceptible beyond those limits, so far as the East River is concerned, does it?

A. I do not understand what does not seem to be perceptible.

Q. The influence of the sewage discharged into the East River as reducing the dissolved oxygen in the water.

A. Outside of this sphere of influence you mean?

Q. Yes.

A. I do not think that there is anything upon this chart which would give one an idea as to whether the results of these dissolved oxygens are due entirely to the discharges in the East River or not, but I should say that the probability was that the larger part of it is due to the discharges of sewers in that region. The amount of it in all these waters, and there is so much surging backward and forward due to the tidal flow that it is very difficult for an engineer to pin it down to any particular point as a cause.

Q. Take the cross-section at the Mt. St. Vincent Hospital?

A. Yes.

Q. Which I think is in a general way above the thickly populated part of New York City, is it not?

A. I should think so.

Q. You will observe that the average of the determinations of dissolved oxygen appears to be 78 per cent?

A. Yes,

Q. And at the Robbins Reef light on October 24, the aver-

2324 age appears to be 78 per cent?

A. Yes.

Q. Well, at the mouth of the Hudson the East River at New York Bay. Of course, the Hudson has no other mouth. I don't know whether the East River properly has a mouth to the Long Island Sound or not. There the dissolved oxygen appears to be respectively 55 and 54 per cent?

A. Yes.

Q. It is a fact that on October 24, at any rate, the dissolved oxygen at Robbins Reef appears to be raised to the same percentage as at the Mt. St. Vincent cross-section, 78 per cent.

A. That is a fact, so far as the figures go, but it does not follow that the oxygen has been raised again in that sense of the word. Of course, these refreshing flows from the ocean into the Lower Bay tend to keep the oxygen high, and on the other hand the fresh water

which is coming down from the Hudson tends to keep that high there.

Q. Yes, the fresh water normally carrying a larger percentage of oxygen than salt water?

A. It normally does carry a larger per cent., but the summer season flow of the Hudson River is very slow comparatively. The flow from the ocean is a constant one practically, varying with storms.

Q. But, so far as it appears from the figures on that chart, Mr. FitzGerald, is it not a fact that the deterioration or depreciation of oxygen content in the waters below the Mt. St. Vincent cross-section down to the mouth of the Hudson River was restored by the time you reached Robbins Reef cross-section?

A. I should think that was a fact.

Q. So that the sphere of influence of the putrescible matter discharged from the vast populations of Greater New York would seem to have largely disappeared by the time you reached Robbins Reef?

A. No, I do not think so by any means.

Q. Well, the free oxygen, the dissolved oxygen content
2325 of the water has been raised from 54 and 55 per cent. at the mouths of the East and Hudson Rivers respectively at New York Bay to 78 on October 24 at Robbins Reef?

A. Yes.

Q. That is a considerable increase in the free oxygen?

A. Yes, but it is in a very much larger body of water.

Q. Certainly.

A. Very much more diluted.

Q. Diluted, and diluted with water carrying a large percentage of dissolved oxygen?

A. That has its effect.

Q. Well, where have you studied the determinations of free oxygen in harbor waters except those that have been submitted to you in New York Harbor?

A. I do not think I have studied them anywhere.

Q. Do you know whether the waters of any of the large harbors show a higher percentage of free oxygen than 78 at any point within their limits?

A. I do not. One moment. I believe that in Boston Harbor the oxygen will show higher than that in places.

Q. At places?

A. Yes.

Q. Is that belief based upon an investigation?

A. Well, it is based on facts which have come to my knowledge in the course of my experience.

Q. Where do you find water saturated with dissolved oxygen?

A. You find it out in the ocean.

Q. Where?

A. In the ocean.

Q. And at what depth do you discover that kind of water?

A. I do not know. I have no data of the oxygen content at great depths in the ocean, and there are parts of the ocean that are very

deep indeed, a number of miles. I have known, I think, but I cannot remember.

Q. Of these determinations at different depths?

A. No.

2326 Q. Well, outside of the open ocean water, where do you find saturated water. I mean saturated with dissolved oxygen?

A. You will find it in pure streams.

Q. Do you find it in any harbor waters that you know of?

A. I think you will find it pretty near saturation in some harbors.

Q. Well, are you basing that statement upon an investigation, or just as a matter of belief?

A. Yes, I do not think many harbors, but I think some.

Q. Will you state one where you have investigated where you found water saturated with dissolved oxygen?

A. Not saturated, I said pretty near.

Q. How near?

A. I should think 85 per cent.

A. And the determinations on October 24, at Robbins Reef, that was 78 per cent?

A. Yes. I should like to modify that answer that I have just given. I think the water in Boston Harbor will show higher than 85 per cent. in many places.

Q. Under what conditions?

A. Well, under the conditions of flood tide, and the tide in Boston Harbor is a very high one comparatively. Nearly ten feet, practically 10 feet.

Q. There is a greater incoming of fresh sea water?

A. Yes.

Q. And when you say that do you mean an average or do you mean selected places?

A. No, there have not been any oxygen determinations to base oxygen averages on in Boston Harbor.

Q. I am asking you what you mean when you say, when you speak of a higher degree of oxygen content in the water of Boston Harbor. Do you mean at selected places or the average?

A. At selected places.

Q. You would not select, for instance, the sewer outlet at Moon Island, would you?

A. Not by any means.

A. That region?

A. No.

2327 Q. But do you take that into account in your averages?

A. Why, I have not given any averages.

Q. Well, at these selected spots, what distance are they from the discharge points of the Metropolitan sewers?

A. There have been very few averages taken of oxygen in Boston Harbor, but the impression that I have of those that I have heard of shows that at times and in places the oxygen was high. Now, the place that you asked me, the discharge of the Moon Island sewer, that is an intermittent discharge only with the ebb tide, and the con-

tents of the water there might show very high at flood tide, and when the sewer was discharging, very low.

Q. Well, we will take Peddocks Island, then; is that an intermittent discharge?

A. At Peddocks Island there is a constant discharge of sewage.

Q. At Nutt Island?

A. Not a very large amount.

Q. At Nutt Island?

A. Yes, not a large amount, and there we have a fine position for the discharge.

Q. But, ultimately, during the 24 hours, the accumulation of sewage in the Metropolitan District is discharged into Boston Harbor, is it not?

A. Yes, but the tides are very strong and the currents are very strong at Peddocks Island and I should not expect to find there very much influence. I do not expect to because in the first place the discharge of sewage is not very great, and then the open roadsted is very large and the tidal extremes are great.

Q. What population do those three sewers serve, Mr. FitzGerald?

A. Well, I do not know exactly.

Q. Cannot you approximate it?

A. I should think it would be a guess—a million people.

Q. And under the conditions which exist?

A. Probably less than that, a great deal—I do not know. In that neighborhood.

2328 Q. Over 500,000?

A. I should think so.

Q. Between 500,000 and a million?

A. Yes.

Q. Approximately somewhere within the range of the present population as you understand it, proposed to be served by the Passaic Valley sewer?

A. Yes.

Q. And the discharge of the sewage from that population into Boston Harbor still leaves, in your recollection of determinations, the oxygen content of the waters of Boston Harbor at places pretty near the maximum of any harbor that you know of?

A. Well, I should not say that, because I know of very few oxygen determinations in harbors of the world.

Q. As to those that you know of?

A. Yes, I think that Boston Harbor is particularly favorably situated for sewage discharges.

Q. The natural conditions there are such that the discharge of sewage from that large population would not have a specially injurious effect upon the waters of Boston Harbor?

A. I do not think the effect is very bad, but it is bad. I have myself seen very bad effects resulting from the discharge of sewage into Boston Harbor.

Q. Unquestionably. Perhaps I go beyond what I intended. I should have limited it to the oxygen content of the water?

A. I think the effect of the sewage discharged at Boston Harbor

is such as not to affect materially the dissolved oxygen in that harbor, except in places, taking the whole mass of the water.

Q. At the immediate point of discharge of course it affects it, there is no question about that.

A. Also in the fields within the influence of the sewage fields, and all that.

Q. Just at the point where the pipes are discharging it is likely that the oxygen would be found to be very low?

A. I mean the sewage fields for distances from the outlet,
2329 but the topographical situation is one which favors a discharge, and they have been arranged and designed with very excellent judgment.

Q. Do you know Mr. William M. Brown?

A. I do.

Q. What position did he hold with the Metropolitan Sewerage Commission in Boston?

A. He was the chief engineer of the sewerage system. A man of high reputation and great ability.

Q. Now, have you made any study of the ultimate sewage digestive capacity of the waters of the Bay of New York?

A. I do not know that I quite understand your question.

Q. Well, I will put it in another way. As I said, I am not a scientific man. I think you said in your opinion when the dissolved oxygen in the waters of the Bay of New York shall have been reduced to an average of 50 per cent. that the danger point will have been reached?

A. No, I did not state it in that language. I stated that I thought under the conditions that exist here in New York that the authorities should not allow the water of the harbor to get below 50 per cent.

Q. I have a note that you said it would be dangerous to the harbor waters.

A. I think it would be dangerous yes.

Q. It is a difference in words, largely?

A. Yes, it is difficult to define those.

Q. Taking the waters of the bay, not including in it Newark Bay or the Kill van Kull, have you made an attempt to determine how much sewage it can digest without reducing the dissolved oxygen below 50 per cent.?

A. I have not, but I have formed a judgment as to the discharge of a large amount of sewage, additional sewage, into the water as affecting that percentage, and I think I have testified to it.

Q. Yes, I now ask you this question to see whether you have attempted to determine how much sewage—or, perhaps, put
2330 it another way—the sewage from how many inhabitants the waters of New York Bay can digest without reducing the dissolved oxygen below 50 per cent.?

A. I can not. I have however—do you refer to 50 per cent. in the whole mass of the water or only at the Hudson River?

Q. I am speaking of the waters of the bay?

A. Of the Upper Bay?

Q. Yes.

A. No, I have not.

Q. Well, in your consideration of this problem for the complainants, have you taken into consideration that the State of New Jersey has any rights in the digestive capacity of the *of the* waters of New York Bay for sewage?

Mr. O'Sullivan: The question is objected to on the ground that you are calling for a judicial determination as to the riparian interests in a common body of water, a question which this witness has not been qualified to answer.

The Commissioner: Note the objection of counsel for complainants.

A. I have.

Q. You have?

A. Yes.

Q. Well, what proportion of the digestive capacity have you taken into consideration as belonging to the State of New Jersey?

Mr. O'Sullivan: The same objection.

The Commissioner: Note the objection of counsel for complainants.

A. While I took into consideration that the riparian owners on the harbor would discharge their quota of sewage into the harbor and that they were discharging into the harbor at the present time——

Q. Did you attempt to apportion that by the relative
2331 amount of shore or ripa that the State of New Jersey and the State of New York each possesses on New York Bay?

A. Well, roughly, in my mind, I think I did take that into consideration.

Q. How much did you apportion to the State of New Jersey on that basis?

Mr. O'Sullivan: The question is objected to on the same grounds.

The Commissioner: Note the objection of counsel for complainants.

A. I cannot state in figures because I did not make any separation in that way.

Q. Well, can you state whether or not the discharge of sewage from the State of New Jersey plus the anticipated discharge from the Passaic Valley Sewer will represent the proportion that the State of New Jersey was assigned in your mind in the digestive capacity of the waters of the Bay of New York?

Mr. O'Sullivan: I object. This witness has not been qualified to answer such questions, and in answering that question he is usurping the functions of the court in this very litigation.

The Commisisoner: Note the objection of counsel for complainants.

A. Yes. I allowed and took into consideration that the discharge from the Passaic Valley would proceed, as it does at present, or would be properly purified and discharged in a purified condition

into the stream and it would so find its way either as at present in a bad condition, passing into Newark Bay, and some 84 per cent. of it through the Kill van Kull, and then the rest of the sewage from the truly riparian part of New Jersey would discharge, as at present, by sewers directly into the waters of the harbor. And I think I stated in my direct examination that I believed it was incumbent on both the State of New Jersey and the State of
2332 New York to unite and see that their combined discharge of sewage was done in a proper way.

Q. Yes, I think you did. I think you also testified that the State of New Jersey should be prevented from discharging this sewage through the Passaic Valley Sewer for several reasons which you alleged?

A. Yes, directly into the harbor.

Q. Having determined in a rough way that the State of New Jersey was entitled to a proportion of the sewage disposal capacity of the waters of the bay, can you state in figures what that proportion is.

Mr. O'Sullivan: I object on the ground that this witness is now being asked to pass judicially upon the rights of the contestant states and this witness has not qualified either by experience or training to pass upon any such questions, and on the further ground that the testimony of the witness was entirely based upon the menace to health and the impending injury to property which would flow from such a discharge.

The Commissioner: Note the objection of counsel for complainants.

A. I cannot. I cannot now state that proportion, but I could do so with sufficient time to compute it and to consider the question, because I think it would be one which would be founded on the difference in population. This is to say that the population, the true riparian population on the New Jersey side of the river, would be entitled to the discharge according, to that population, directly into the waters of the harbor, on account of their being what I consider true riparian dwellers.

Q. In other words, that the first that could grab it
2333 would be entitled to it?

A. No, not at all.

Q. Then, it would be based upon the actual shore line, the proportion of the shore line?

A. The population on that shore line.

Q. The population that happened to exist at any particular time would determine the rights of the two states in your judgment?

A. The amount of sewage would be measured, that is what you asked me.

Q. No, I ask you what amount they would be entitled to, not what amount they had taken possession of.

Mr. O'Sullivan: I object on the ground that it calls for a judicial

determination by this witness as to the rights of the defendants in this very litigation.

The Commissioner: Note the objection of counsel for complainants.

Q. Will you answer the question?

A. I do not feel competent to answer that question.

Q. You think that is a legal question, do you?

A. Well, I think it is largely a hypothetical question which never came up in my practice.

Q. What is the hypothesis that you refer to?

A. Well, defining the right in quantity or giving a quantitive value to a proprietor to drain into a stream and defining it by figures.

Q. You think that is rather an absurd question, do you?

A. No, I did not say absurd because I should not want to characterize any of your questions by such a term. I have not seen anything absurd in any of them, Mr. Riker.

Q. In your judgment does the adventitious existence of population on a ripa determine the rights of states, which border on a body of water, so far as sewage is concerned?

2334 Mr. O'Sullivan: I object to it for the reasons given as to the last question.

The Commissioner: Note the objection of counsel for complainants.

A. If I understand your question, Mr. Riker, it is somewhat like the preceding one, which attempts to get from an engineer more or less of a judicial declaration on the rights of the parties, and I have not had practice enough to give an expert answer.

Q. Now, Mr. FitzGerald, will you tell me if you can, what proportion of the sewage digestive capacity of the waters of the Bay of New York will be used in the caring for of the sewage of a population of 750,000 inhabitants, discharged at Robbins Reef through the projected Passaic Valley Sewer, as you understand that project?

A. I should believe that no part of it should be used for that purpose.

Q. Should be used?

A. Yes.

Q. I did not ask you that question.

A. Yes, you asked me——

Mr. Riker: Repeat the question, Mr. Stenographer.

(Question repeated by the stenographer.)

A. I do not think any of it will. I do not think the scheme will be allowed.

Q. That is a legal conclusion, is it not, Mr. FitzGerald?

A. No, it is an engineering conclusion.

Q. Do not you think it is practicable to build the sewer?

A. Yes, practicable, but I do not think it will be allowed.

Q. That is a legal problem, whether it will be allowed?
A. Yes, I suppose it is largely.
Q. Well, using the hypothesis that it is allowed, then what percentage of the sewage capacity will be used by that discharge?
2335 A. I think a considerable portion of it would be used.
Q. How much?
A. I cannot state.
Q. Cannot you approximate it?
A. I cannot.
Q. You are not willing to put yourself on record on any percentage?
A. I am not.
Q. Are you willing to say 16 per cent. will be used?
A. I am not willing to state any percentage.
Q. Now, Mr. FitzGerald, taking the stipulation between the United States and the State of New Jersey and the Passaic Valley Sewerage Commissioners, which I think you say you have studied?
A. Yes.
Q. And assume that the sewage will be discharged at Robbins Reef in the manner specified in that stipulation, without any additional treatment, any changes in the specifications, what distance from the point of discharge, in your opinion, will the fact of that discharge be perceptible in any way?
A. To the distance of several miles.
Q. In what way will that discharge be perceptible for a distance of several miles?
A. The effect of the discharge of this proposed sewage at Robbins Reef will be to inject into the harbor, the Upper Bay at Robbins Reef, or near Robbins Reef, a very large mass of sewage, in very bad condition, which will be very highly polluted, which will seize oxygen with great avidity, which will lower the percentage of oxygen. To what extent, it is impossible for me to now state. But it will lower it materially in my judgment all around the borders of the Upper Bay, and extending beyond those borders up the Hudson River and to certain distances into all the inland waters connected with that harbor. The fact that that sewage will contain a large amount of turbid material, which will be in a condition to produce a bad effect upon water, and that the liquid and colloids will
2336 also be highly putrescible. I believe that the effect of the discharge of such a very large mass of sewage will be very detrimental and will be felt a great distance, depending largely on local conditions.
Q. Now, then, the effects which will be perceptible for several miles will be the reduction in the amount of free oxygen, dissolved oxygen in the waters. Taking it now in itself, and without reference to the pollution by the cities of the State of New York discharging into the bay, to what point do you think that that reduction in the dissolved oxygen will amount to a net result of below 50 per cent. of dissolved oxygen in the water?
A. I do not understand that question. Do you mean at what points will it be lowered below 50 per cent?

Q. Yes. How far from the point of discharge will the free oxygen be reduced by that discharge below 50 per cent.?

A. I cannot very well define that. It is almost impossible, although I should like to do it and I should like to meet your question honestly and fairly, but the problem is too difficult a one for me to solve on the stand.

Q. So far as you know has there been any attempt made to solve that problem?

A. Only in a general form. That is to say, wherever the dissolved oxygen in the waters today is represented by the figure of 50 per cent., it must inevitably be materially lowered after this discharge. Now, it is absolutely impossible for me, especially on the stand, to select places where the dissolved oxygen will be lowered below 50 per cent.

Q. The other effect that you have testified to, is that a visible effect that you have in mind; something that is perceptible to the eye, I mean?

A. I do not know, Mr. Riker, that I understand your question.

Q. What I intend to direct your attention to is that
2337 you said that the effect of the discharge upon the waters of the Passaic Valley Sewer as proposed will be perceptible for several miles, first by the reduction of the free oxygen and after that by certain other things that you described?

A. Turbidity, I think I spoke of turbidity.

Q. Colloidal *matteral* I think you spoke of?

A. For instance, the colloids would be difficult to see by the eye except at first, probably, but the effect would be felt for long distances.

Q. In the reduction of the dissolved oxygen?

A. Yes.

Q. Then it is all one thing?

A. Yes.

Q. Do you anticipate the formation of sewage fields about this point of discharge?

A. Yes.

Q. You would?

A. Certainly.

Q. And sleek fields?

A. Certainly.

Q. And odors?

A. Certainly.

Q. Emanating from sewage matter?

A. Certainly.

Q. Well, now, in dicussing this stipulation, as I remember it, you said that you did you think the results of this sewage discharge would be easily determinable, did you not?

A. Not as separated from the other sewer discharges. It would simply be practically impossible to say that that particular particle of sewage came from this sewer or some other sewer.

Q. Now, Mr. FitzGerald, if there is a sewage field and a sleek field formed at the point of discharge is there any difficulty in determining

with reasonable certainty that it is due to the discharge from that sewer?

A. Well, I have always found it very difficult to convince a judicial authority of that fact. I have had some experience on it too. I might say a good deal of experience.

Q. Then your doubt is as to the receptivity of the judicial
2338 mind of the impression of the actual facts of the formation of separate fields of sewage and sleek in the middle of the harbor?

A. Partly, and partly to a professional difficulty in determining it to begin with.

Q. Do you mean by that, difficulty in determining that there exists a sewage field?

A. I think there would be difficulty for a man to testify to it, that it comes from one particular source. He might be fairly convinced of it himself.

Q. How far from the shore line, the nearest shore line, if you know, approximately I mean, is the proposed point of discharge of this Passaic Valley sewer?

A. My impression is that the nearest point, as far as I can judge from a glance at the chart, would be Richmond.

Q. And how far is that?

A. Well, I should think it was a mile.

Q. And do you anticipate the formation of a defined sewage field about the point of discharge from the proposed sewer, if it is ever put into operation?

A. I should expect to find such.

Q. Do you think there is difficulty in identifying it with its source under those conditions?

A. It would be difficult to convince a court that it came undoubtedly from that source.

Q. Now, Mr. FitzGerald, will you answer this question. Would you have any difficulty in identifying the cause of such a sleek field and sewage field if formed about Robbins Reef, so far as you are concerned?

A. I do not think that I should.

Q. Do you think that any reasonable human being with ordinary powers of observations would have any difficulty in attributing the presence of a sleek field at that point to a sewer discharging
2339 at that point?

A. I don't think it ought to be difficult to convince reasonable human beings of it.

Q. Well, Mr. FitzGerald, assuming a dissolved oxygen content in the waters about Robbins Reef of over 70 per cent. before the discharge at that point of the sewer of the kind proposed, and assume that there is discharged thereafter sewage from a population of 750,000 inhabitants of the kind that you have observed in the Passaic Valley, at what point, with reference to the point of discharge, do you think the oxygen content will be reduced to 54 per cent?

A. I am unable to state.

Q. Then the dangers that you anticipate in the way of the reduction of the dissolved oxygen in the waters of the bay is in the line of

reducing the corrective powers of the waters upon the bad conditions produced by the discharge of the sewage of New York City directly into the bay?

A. What do you mean by corrective?

Q. The raising and replenishing of the oxygen that has been exhausted in the discharge of polluted matter from the city of New York?

A. No. My objection is that by the concentrated discharge of this large mass of putrescible sewage into the Upper Bay, that the corrective powers, if you term it such, or the margin of dissolved oxygen remaining in the waters will be so largely reduced all around the margins of that bay from all the streams that the refreshing or corrective power, which is I think the term that you used, will be materially reduced.

Q. Well, do you think the discharge of a population of 750,000 inhabitants, as proposed at Robbins Reef, will be felt in the reduction of the dissolved oxygen in all the waters of the harbor of New York?

A. Yes.

Q. In what way, directly?

A. Yes.

2340 Q. And are you now, having considered the matter up to the point of giving that answer, are you now prepared to say up to what points from the point or place of discharge the effect will amount to a reduction below 50 per cent. in the dissolved oxygen in the waters?

A. I cannot define it in that way.

Q. How, far, from your observations and from consideration of the determinations of dissolved oxygen in the waters of the Bay of New York have you found that the discharge of crude sewage of the inhabitants of Greater New York affects the waters in the Bay of New York in the reduction of its free oxygen?

A. I have found by personal examinations around the margins of that bay that the condition of the water is very foul. That even in the central part of the bay the dissolved oxygen has been reduced about 25 per cent., and that there are many places around the margin of that bay where large masses of water are today, under present conditions, so low in dissolved oxygen that I feel alarmed. That under the continuous discharge of sewage due to the increased population the time will soon arrive when the waters will be so foul as to be a great menace to the interests in New York.

Q. Now, can you state in a general way the number of human beings discharging sewage into New York Bay at the time when these observations were taken?

A. It would have to be a guess.

Q. A rough guess?

A. A rough guess would be five or six million people.

Q. And at Bobbins Reef where these averages have been attempted to be determined that sewage has reduced the dissolved oxygen to percentages represented by 72, 74 and 78 on the chart which is in evidence?

A. Quite true, but it must be borne in mind that large
2341 portions of that population have been discharging their sewage into large masses of water far distant from this point, and where the refreshing influence of oxygen has had opportunity to work.

Q. Now, how many of the five or six millions ought to be included within that effect?

A. Well, you take all the population of the Island of Manhattan. That portion of the population discharging into the Hudson River. That sewage has passed several miles of distance and come in contact with a great deal of water. You take that population on the Harlem, which discharges into the Harlem River, that sewage has been passing backward and forward and has been submitted to a large amount of influence. You take that in the East River, the same. And you take that in the Passaic River itself, that has had the chance of going through Newark Bay, where it has been exposed to the influence of oxygen.

—. Now, confining your attention to Manhattan Island, the results of the passage of the sewage through these large bodies of water, as indicated by the chart, is that when they reach the bay proper the dissolved oxygen has been reduced in one case to 54 per cent. and in the other case to be 55 per cent?

A. Yes.

Q. And that condition of the water has changed when you reach Robbins Reef to a percentage of 72, 74 and 78?

A. I have already covered that fully. I have given you my views upon it.

Q. And you think and still maintain the position that the discharge of the sewage of 750,000 inhabitants at Robbin's Reef will have an effect upon the shores of Manhattan to perceptibly reduce the dissolved oxygen in the waters there, do you?

A. Yes.

Q. Now, Mr. FitzGerald, you were asked to state whether you had read a certain hypothetical question and you said that
2342 you had?

A. Yes.

Q. Now, I direct your special attention to that part of it which asks your opinion as to the results of the contemplated discharge from the Passaic Valley Trunk Sewer outlet into New York Upper Bay in the vicinity of Robbins Reef, and ask you just what the contemplated discharge was which you had in mind when you answered that question?

A. The contemplated discharge which I had in mind was the discharge which would be likely to come through a tunnel of the size and position which was described as forming the scheme of the Passaic Valley Sewerage Commissioners, and connected, as they have described, with the different towns and cities along the Passaic Valley.

Q. Now, when you use the word "contemplated" in that connection, what do you understand to be the application of that word? Does it mean a specific plan or does it mean something which you imagine may be done?

A. It means a specific plan.

Q. Now, what is that plan?

A. That plan is to collect the sewage from the towns and cities, and the boroughs in the Passaic Valley in an intercepting sewer which shall extend to Newark Bay and there tunnel under Newark Bay and under the city of Bayonne, and under the harbor of New York, the Upper Bay, and discharge as described by the engineer who designed that scheme into the upper bay waters.

Q. Well, that describes the machinery, the means of discharge. But what is the contemplated discharge itself that you have in mind when you testify in answer to this question?

A. The contemplated discharge which I had in mind was what would result naturally from such a form of construction, connected with the sewers at those different places.

Q. That is all you had in mind?

A. The growth in the future.

2342½ Q. And that is all you had in mind?

A. Yes, sir.

Q. And you did not have in mind as being contemplated the specification contained in the stipulation between the United States and the State of New Jersey and the Passaic Valley Sewerage Commissioners?

A. Certainly, I had those in mind too.

Q. How much of that did you have in mind when you gave your answer?

A. How much of it, every bit of it, every letter and comma and period.

Q. Do you remember what your answer was to that hypothetical question?

A. I do.

Q. What was it?

A. I considered that the effect would be extremely deleterious.

Q. To what?

A. To the interests of New York.

Q. To the interests of the State of New York. So that when your attention was directed thereafter specifically to this stipulation, you had already considered it in giving your answer to the hypothetical question?

A. Yes.

Q. Did you in answering that question have in mind that the contemplated discharge involved the proposition that there will be absence in New York Bay of visible suspended particles coming from Passaic Valley sewage?

A. I did.

Q. And that there will be absence of deposits objectionable to the Secretary of War in New York Bay coming from the Passaic Valley sewage?

A. I did, so far as they are mentioned in those specifications.

Q. And there will be absence in New York Bay and vicinity of odors due to the putrefaction of organic matter contained in the Passaic Valley sewage discharged?

A. I did, so far as mentioned in this stipulation.

Q. Will you give me the original exhibit so there will be
2343 no mistake that I am reading the whole of it?

(Witness examines original exhibit.)

Q. And that there will be a practical absence on the surface of New York Bay of any grease or color due to the discharge of Passaic Valley sewage at the dispersion area or elsewhere?

A. I did under the conditions mentioned.

Q. What are the conditions that you are interjecting into this?

A. Those conditions are clearly mentioned in the preceding paragraphs by clear and distinct description of the works by which these results are to be secured.

Q. I will now go back and ask you whether the contemplated discharge that you had in mind in your answer involved the declared intention of the Passaic Valley Sewerage Commissioners in the operation of the sewerage system at all times to produce the following results, either through compliance with the requirements of the immediately preceding paragraphs, referring to the specific means enumerated, or through requisite lawful additional arrangements. Had you that in mind?

A. I did.

Q. And that the discharge contemplates there will be absence in New York Bay of visible suspended particles coming from the Passaic Valley sewage, either by the means named, or by other requisite lawful additional arrangements. Had you that in mind?

A. Yes, but I do not know what lawful arrangements means, I must confess.

Q. Filtration would be a lawful additional arrangement would it not?

A. I should call it—I think if filtration was meant it would be more clearly defined than that. I thought when I read that that it meant some legal arrangement.

Q. Legal?

A. Yes, I could not understand it.

Q. You do not distinguish in language between "legal" and "lawful". You do not know what lawful means?

A. I did not attempt to make any distinction.

2344 Q. Do not you know what "lawful" means?

A. I know the ordinary use of the word lawful.

Q. Applying the ordinary meaning to "requisite lawful additional arrangements," do you mean to say that the results in your opinion cannot be produced?

A. I do.

Q. Do you mean to say that in your opinion they cannot be produced?

A. I do.

Q. Why not?

A. Because with anything like the arrangements specifically mentioned as producing those results it would be impossible to do it.

Q. Now, Mr. FitsGerald, I am evidently up against some mis-

understanding of language. I do not clearly express myself. Do you mean to say that through the adoption of additional arrangements to those specified in this contract or stipulation that the results stipulated by the State of New Jersey and the Passaic Valley Sewerage Commissioners cannot be produced in the Bay of New York?

A. I think that is true, but at the same time I am bound to tell you that that is not the language of the stipulation.

Q. Well, do you mean by that that I am not reading the language correctly?

A. I mean you left out one word.

Q. I left out the word "lawful"?

A. Yes.

Q. What ones of these arrangements which will produce in your opinion the results stipulated is not lawful?

Mr. O'Sullivan: The question is objected — as calling for a determination of the legal value of an arrangement which this witness has not been qualified to pass on.

The Commissioner: Note the objection of counsel for complainants.

2345 A. I am not accustomed to consider that wonderful engineering results can be accomplished by lawful arrangements.

Q. Are you in the habit of producing wonderful results by unlawful means; is that what you wish to be understood as saying?

A. No.

Q. How do you produce them, by lawful or unlawful means?

A. I produce them by works which are just as carefully described as those works are described in the preceding paragraphs.

Q. Now, I want to press you a little further Mr. FitzGerald, if you do not mind, and ask you whether there are not engineering devices in addition to those specified in this stipulation which will produce the results which are stipulated to be produced in the harbor of New York in the discharge of the sewage from the Passaic Valley proposed sewer?

A. I do not think it is practicable by engineering devices, however carefully designed, however expensive in construction, however elaborate in detail, to accomplish all those purposes.

Q. You do not think that is possible; what ones are not possible?

A. I do not think it is possible—practical is the better term, perhaps—to secure absence in New York Bay of visible suspended particles coming from Passaic Valley sewage.

Q. What other is not practicable of the stipulations?

A. I should think that was the principal one, perhaps the sole one.

Q. Well, in answering the hypothetical question did you not understand the discharge that is contemplated by the Passaic Valley Sewerage Commissioners is as described in this stipulation between the United States and the Passaic Valley Sewerage Commissioners and the State of New Jersey?

A. I did.

2346 Q. Did you understand it so?

A. I did.

Q. You did understand it so?

A. Yes.

Q. And assuming that the discharge so contemplated is properly described in this stipulation as follows: There will be absence in the New York Bay of visible suspended particles coming from the Passaic Valley sewage; there will be absence of deposits objectionable to the Secretary of War of the United States in New York Bay coming from the Passaic Valley sewage; there will be absence in the New York Bay and its vicinity of odors due to the putrefaction of organic matters contained in the Passaic Valley sewage thus discharged; there will be a practical absence on the surface of New York Bay of any grease or color due to the discharge of the Passaic Valley Sewage at the dispersion area or elsewhere; that there will be no injury to the public health which will be occasioned by the discharge from the said sewer into the Bay of New York in the manner proposed and no public or private nuisance will be created thereby, the absence of injurious effect from said sewage discharge, upon the property of the United States in the Harbor of New York; the absence of reduction in the dissolved oxygen contents of the waters of New York Bay, resulting from the discharge of Passaic Valley sewage, to such an extent as to interfere with major fish life. Having that in mind as the contemplated discharge, so described, do you mean to say in your opinion that that will be deleterious to the State of New York?

A. My judgment was not formed in taking any one part of this instrument. My answer to that hypothetical question was based on taking the whole instrument in accordance with what I deemed to be a reasonable construction of it.

Q. Then you did not take that as the description of the contemplated discharge of this sewer into the waters of New York Bay?

A. Certainly not.

2347 Q. You studied the stipulation?

A. I did.

Q. And you recognize that as the description in the solemn compact of the proposed discharge, do you not?

A. I do.

Q. And you did not take it into consideration?

A. I took every particle of that instrument into consideration and gave due weight to every part.

Q. In your opinion you did, you mean.

A. In my opinion, to the best of my ability.

Q. And you gave no weight to the statement in this stipulation that these results will be produced either through compliance with the requirements specified or through requisite lawful additional arrangements?

A. On the contrary I gave due weight to that.

Q. What significance did you give to that last clause of that proposition?

A. I gave the utmost significance that I could under the construction of all the paragraphs of the whole instrument.

Q. Do you mean to say that there are no efficient additional arrangements recognized in engineering science beyond those named in this stipulation which will tend to produce the results stipulated for?

A. I do nothing of the kind.

Q. Now, Mr. FitzGerald, I think one reason given by you for your opinion that New Jersey should not be allowed to discharge sewage at the point indicated in the plan was that the Metropolitan Sewerage District Commissioners were devising plans to purify their own waterfront?

A. Yes, not only their own, Mr. Riker, but the whole Metropolitan District.

Q. Well, did you not specify some plan of discharging the sewage through interceptors at some point on Long Island where sewage purification could be applied?

2348 A. That was an original plan, Mr. Riker, one of the early ones which I was describing, in the course of development.

Q. That was just a plan that had been considered without any serious thought of adopting it?

A. Yes, at that time, and since that time they have been studying the discharge of the sewage of the whole Metropolitan District into the open ocean.

Q. Well, a rather good step in that direction would be the concentrating by an interceptor at Robbins Reef, would it not?

A. I do not think so.

Q. Do you not think that would be a good plan to deliver the Passaic Valley sewage?

A. I do not think it would be a good place to deliver any sewage.

Q. Well, why do you apply, Mr. FitzGerald, to the city of New York requirements other than those which in your testimony you have attempted to apply to the Passaic District?

A. I do not. I deny that distinctly.

Q. Let us see whether you do. Did not you testify that one of the reasons why the State of New Jersey should not be allowed to discharge its sewage within its own jurisdiction at Robbins Reef was that these municipalities should establish separate disposal works and discharge the effluent directly into the Passaic River?

Mr. O'Sullivan: I object to that, as at no time in this witness's testimony have there been raised any jurisdictional questions either as to New Jersey or New York.

The Commissioner: Note the objection of counsel for complainants.

A. I have certainly, all through my testimony, I think, been consistent on that point that I have not considered division lines in any way. I have considered it wholly from a topographical

2349 point of view, and I think if you examine my testimony in detail you will find I have condemned the city of New York

and the State of New York just as I have condemned the State of New Jersey.

Q. That is not the question I am asking now, Mr. Fitzgerald. I have no doubt that would be quite correct. I ask whether one of the reasons that you alleged for the prevention of the discharge by the State of New Jersey of this sewage into New York Bay was not the fact that these muicipalities in the Passaic Valley should install separate purification plants and discharge the effluent into the Passaic River?

A. I did not use the word "should," I said they could and I think I might go so far as to say that they should rather than to discharge it in the way they propose.

Q. Rather than to discharge it in the way that they propose?

A. Yes.

Q. Well, you think that method is applicable to New York and Brooklyn?

A. I do not, no.

Q. Why not?

A. Because I have not studied the question sufficiently to determine.

Q. It is purely an engineering problem?

A. Purely an engineering proposition, but the conditions are exceedingly complicated, and New York, the Island of Manhattan and Brooklyn, are not in the condition that those municipalities are upon the Passaic River.

Q. In what respect?

A. They have not the land and the opportunities for purifying their sewage to the same degree that they have.

Q. Then it is purely a financial problem?

A. No, purely a topographical as well as financial problem.

Q. You mean to say that there could not be, as an engineer-
2350 ing problem, purification plants established on the Island of Manhattan?

A. I do not say so, but I do say that there is not naturally the same opportunity.

Q. You mean by that that it would cost more to do it?

A. I mean to say that the engineering difficulties and the financial difficulties are very much greater.

Q. In what respect are the engineering difficulties more difficult?

A. Because in a municipality, a town or a city, situated as all of those that I have seen in the Passaic Valley are, the opportunities of availing themselves of many of the methods of scientific purification are very much greater than they are in a city situated as Manhattan is.

Q. Now, in what respect are they greater?

A. Because they have large areas of land where they can erect their works at reasonable expense.

Q. That is what I thought. It is a financial problem is it not?

A. Largely.

Q. When it comes to the last analysis?

A. It is the topographical situation and the financial, and all the conditions connected with the municipalities.

Q. Is there anything in the topographical condition of the Island of Manhattan which will prevent the installation of disposal and purification plants within the Island that would be sufficient?

A. I do not know.

Q. You have not made a study of it?

A. No.

Q. You do recognize a very considerable financial difficulty?

A. That is a pretty difficult question to answer on the stand.

Q. What, the last one?

A. Both.

Q. I say you do recognize a serious financial difficulty in the of Manhattan?

2351 A. I realize that the resources of the Island of Manhattan are very astounding to a country man who comes from Boston.

Q. Now, is not the difficulty, Mr. Fitzgerald, in the situation you have been studying, that the city of New York, through its disregard of the sanitary precautions in the disposal of its sewage has established a condition in the waters of New York Bay, particularly about the shores of New York City, which is in itself dangerous?

A. That is one of the difficulties, but it is not confined to the City of New York.

Q. And in so far as it is not confined to the City of New York it is a resultant of the neglect of sanitary precautions by that city?

A. Yes, and the State of New Jersey itself.

Q. Whereabouts?

A. Why, there are nuisances existing on the Jersey side.

Q. Do you think they affect New York?

A. Just as there are in and around Newtown, not the same degree perhaps.

Q. Do you think they affect the city of New York, those nuisances?

A. It all affects the water we are talking about.

Q. And under the conditions which have thus been established by the city of New York, it would be desirable to eliminate as much as possible the consumption of dissolved oxygen from any part of the State of New Jersey, so as not to interfere with the monopoly in the free oxygen in the waters by the city of New York?

A. No, I entirely protest against any such thing, that never passed through my mind. What is in my mind is that all the municipalities should unite and form an intelligent study of the problem as a whole, and that no part of it should seek to grab any part of the harbor.

2352 Q. But those that have grabbed it should be allowed to retain it without attempting to do anything to show their good faith before preventing other people from using any part of it?

A. I do not think so at all.

Q. What is the city of New York doing to clean its own skirts, if you know?

A. I am sorry to say they are doing much less than I should like to see them do.

Q. Well, what are they doing

A. They have formed a commission to study it and are engaged now in studying it, and have invited the State of New Jersey——

Q. The chief function, so far as you know, has been the prosecution of this litigation in the United States Supreme Court?

Mr. O'Sullivan: That commission has nothing to do under the Heavens with the prosecution of this suit.

The Commissioner: Note the objection of counsel for complainants.

A. No, I do not consider that that has been the chief function of the city of New York. I think that the chief function has been to begin and to make, through the last few years, a careful scientific study of the whole subject.

Q. As a matter of fact, what thing have they done, or what thing have they studied that has not had reference to this litigation, so far as you know?

A. I should think they have done a great many things. To my knowledge they have.

Q. What?

A. They have begun a serious study of the present condition, in the first place, of the harbor waters and in the next place they have made very extensive surveys and employed a large number of experts to give them advice as to the most necessary and practical way to deal with this great question.

Q. What else?

A. I have nothing more to say.

2353 Q. That is all you know about it?

A. Well, I do not know much.

Q. Now, you testified, Mr. Fitzgerald, that the proposed sewage discharge at Robbins Reef was an unnatural outlet for the Passaic Valley sewage. In what respect is it an unnatural outlet?

A. Because it is not one that has been provided by Nature.

Q. You mean by that Nature would not have built the sewer, is that what you mean?

A. Yes.

Q. You do not mean by that that the natural drainage of the Passaic Valley does not discharge almost entirely into New York Bay?

A. I do.

Q. You do mean that?

A. I do.

Q. Where does it discharge?

A. I mean that it is only a portion of it.

Q. What proportion of it discharges into New York Bay?

A. A very small portion of it directly; a considerable portion indirectly, and a smaller proportion into the Arthur Kill.

Q. Now, taking the indirect and direct discharge into New York

Bay, what percentage of the total is that? Did not you testify to it as 84 per cent?

A. No.

Q. Was it 86?

A. No, I testified that of the indirect drainage through Newark Bay 84 per cent. passed into the waters of the harbor.

Q. That indirect drainage was 84 per cent; what is the direct drainage?

A. The direct drainage did not occur in the consideration of that portion of my testimony at all. We were there measuring that the 100 per cent. was the indirect drainage. That is, the whole Passaic Valley drainage, 84 per cent. of which passed indirectly into New York Harbor, and 16 per cent. into the Arthur Kill.

Q. Then we are not so far apart after all. 84 per cent. of the drainage of the Passaic Valley finds its way by a means pro-
2354 vided by Nature into New York Bay?

A. Indirectly.

Q. You mean by that through the medium of Newark Bay?

A. Yes.

Q. And the Kill van Kull?

A. Yes.

Q. But nevertheless through an underground sewer or tunnel, it finds its way through an open stream to New York Bay, does it not?

A. Yes, but there is a great difference between the two.

Q. In the sense in which you are testifying to it as an unnatural outlet, every sewer that is constructed is an unnatural outlet?

A. No.

Q. How does it differ?

A. Why, all the sewers of Jersey City, and of the part of New Jersey boardering directly on the Upper Bay, the sewers may and do pass directly into that bay. Now, when you come to collect all the sewage of a great inland community like that of the Passaic Valley and carry that down directly by the shortest cut through a tunnel, then you carry out what I have characterized as an artificial discharge.

Q. Unnatural?

A. An unnatural discharge.

Q. Do you know the Bronx Sewer; the Bronx Valley Sewer?

A. I know there is one.

Q. You have never examined it?

A. I have seen the outlet.

Q. Do you know what territory it serves?

A. I think I do.

Q. Is that an unnatural outlet for the Bronx Valley?

A. Well, I do not think it is unnatural in the same sense that I have been speaking of the Passaic.

Q. Why not?

A. Well, because the Bronx River discharges directly into
2355 the harbor waters.

Q. Well, does not the Passaic River discharge directly into the harbor water?

A. No, it discharges into Newark Bay first.

Q. And you said that Newark Bay was part of New York Harbor?

A. It is part of the harbor waters, in that larger sense of the term.

Q. That is elastic?

A. It is elastic only in an engineering sense, that you have an opportunity for the sewage there to come into contact with a large mass of oxygen.

Q. Then you say you do not think the Bronx Valley sewer is an unnatural outlet for the sewage of the Bronx Valley?

A. Well, I should like very much to study that more without giving that opinion, because I really never have considered it.

Q. You know there is a Bronx River, of course?

A. I do.

Q. Just as there is a Passaic River?

A. Not in just the same way.

Q. They are two different rivers, but they are both rivers and they both have drainage areas?

A. But they both discharge in quite a different way into harbor waters. Each discharges in quite a different way into the harbor waters. It may have been an unwise thing for the city of New York to have built the Bronx Valley sewer. That I do not know about.

Q. Now, you have testified to some dangers to persons navigating New York Bay from this discharge, as proposed, into the harbor from the Passaic Valley sewer. Just what is that danger, to your mind?

A. I think there are a great many dangers. I think, in the first place, there is danger of contamination, of disease to human beings.

Q. In what way?

A. First, by the water being blown directly into the mouths of persons navigating it, and in the next place by coming into
2356 bodily contact with their systems in using it in different ways, such as washing boats, etc., and then I think it is very detrimental for the shellfishing industry. I think that another way in which it is detrimental is in its effect on——

Q. Dangerous, I think, was the word you used?

A. Dangerous, yes; dangerous to health.

Q. Dangerous to those navigating the water?

A. Yes, dangerous to the health of those navigating the water. Also dangerous to the health of the people. Do you want me to confine it to navigation?

Q. Yes.

A. I think it is dangerous for pleasure boats. I have seen the effect of it myself. I have seen the effect on pleasure craft and on commercial craft.

Q. Won't you confine it to dangers to those navigating the waters; tell me what the dangers are in your judgment to those navigating the waters?

A. I have described them, the dangers, as far as dangers to health are concerned you mean?

Q. What other danger is there to those navigating the water?

A. Are you confining me to that word "danger"?

Q. I am only confining you to what you testified to yourself, Mr. Fitzgerald?

A. Did not I state other words besides danger?

Q. My recollection is that you described the dangers to those navigating the water from this proposed Passaic Valley Sewer. I want to know what those dangers are specifically, if you can point them out?

A. I have described them.

Q. You described the shell-fish industry. You will eliminate that, won't you?

A. I have described other things than the shell-fish industry.

2357 Q. You have described the injury to pleasure craft; you will eliminate that from the answer, won't you?

A. It is you that eliminates it, Mr. Riker.

Q. I ask you to answer the question?

A. I think I have answered it.

Q. Will you answer it again so as to avoid any confusion in regard to it. What are the specific dangers, in your judgment, to those navigating the waters of New York Bay from the proposed discharge of the Passaic Valley Sewer?

A. I think it is likely to cause death.

Q. In what way?

A. Through coming into contact with the water directly blown into their mouths or onto their persons, and indirectly by the use of that water for any purpose that it is used for by navigators.

Q. Those are the dangers that you anticipate, the spray blowing into the mouths of persons, or the use of the water by navigators in other ways?

A. Yes.

Q. What other ways do the navigators use the water?

A. They use it for condensing purposes, and for boilers, and for swabbing decks, and if they fall overboard they are pretty apt to get it all over.

Q. That is a danger that might be present in any kind of water to those navigating it, falling overboard?

A. Not to the same extent.

Q. Can you point out any instance of anyone having an injurious effect from the water blown into their mouths or on their persons containing sewage?

A. I cannot.

Q. Do you think the danger at the point of discharge will compare in any way to the danger existing in the slips and along the pierheads of the Greater City of New York?

A. I do not think it will be any worse, or as bad, perhaps.

2358 Q. It would not be as bad?

A. I think it would be as bad, yes.

Q. Would be as bad down there as along the piers?

A. Yes, directly over the outlet.

Q. And you have in mind, of course, the contemplated discharge as described in the stipulation between the United States and the State of New Jersey?

A. Yes, all the time.

Q. What particular disease have you in mind as constituting that danger?

A. Typhoid is the one that we know most about.

Q. You have referred to the shell-fish industry in this harbor as injuriously affected by the sewage. Is it not, as a matter of fact, destroyed now, from a hygienic point of view, by the existing pollution of the harbor waters?

A. I do not know. It is very much endangered, I think. I do not know whether it is destroyed.

Q. In your opinion; are you an expert on hygiene?

A. No. Certain portions of it I think I am. I have spent all my life on it. I mean by that I have devoted my energies for thirty years to protecting people by pollution from impure water.

Q. Do you think in your consideration of this proposed or contemplated discharge that that discharge is likely to have any appreciable injurious effect to that already produced by the pollution of the water of the city of New York?

A. Yes, sir.

Q. In what way?

A. Because there are great masses of filth in that already now existing, and it will concentrate it in one great mass right in the center of the harbor, where it does not exist today.

Q. It being concentrated now, so far as the pollution and filth is concerned, immediately along the shore front of the city
2359 of New York?

A. Yes, quite right.

Q. Do you know where the shell-fish industries are carried on in this harbor?

A. I am not very familiar with them. I have seen some of them at work.

Q. When you testified to injuries to shell-fish interests, you were testifying to the general pollution that it is a bad thing to introduce into waters where shell-fish are being cultivated for consumption by human beings?

A. Yes, and specifically in this case.

Q. Now, when you testified on your direct examination, Mr. Fitz Gerald, in regard to the difficulty in detecting the results of this discharge, this proposed discharge, into the waters of New York Bay, so as to apply and enforce the stipulation, what kind of a discharge did you contemplate in that testimony?

A. I contemplated such a discharge as would be naturally produced by the construction of a series of works, such as that described in that instrument.

Q. And you think that a discharge of the amount which you have been testifying to as likely to occur within and up to the period of 1940 would be difficult to distinguish so as to apply this stipulation in the waters of New York Bay?

A. Yes, I think it would be difficult. Practically impossible to convince a judicial authority that the sewage was identical with that coming from this Passaic Valley.

Q. Is that due to a profound distrust of judicial acumen?

A. No, it comes from a great deal of experience in similar cases with the judicial mind, which requires definite proof, and I may illustrate, perhaps, by giving you the result of some of my experience with courts in getting injunctions against actual sewage discharges in the actual public water supplies, where it is evident to any man of any common sense, such as you have described, that the
2360 discharges were there, and the ordinary proof was not accepted.

Q. That was the slowness of the judicial process that you are complaining of more particularly?

A. I think not. I think it comes from the extreme desire of the judicial mind to be absolutely sure of the facts.

Q. Well, in your opinion, would the existence of the fact of the pollution from this source, if it was established in New York Bay, be at all obscure?

A. Well, I think it would be extremely difficult to connect it in such a way as to produce a stoppage of the discharge.

Q. Well, I know—but do you think that the result——

A. Or the construction of extensive works to modify it.

Q. Do you doubt that the fact of the pollution would be so evident as to be properly termed demonstrable?

A. What I have in mind is exactly this, Mr. Riker. In order to secure an injunction against that discharge, or to secure an appropriation of a very large sum of money for the necessary works to produce such a condition as you mention in this stipulation, and the part of it which declares that there will be no visible suspended particle discharged into the harbor.

Q. That is not right.

A. Pardon me one moment.

Q. There shall be absence in the Bay of New York of visible suspended particles?

A. That is right, of visible suspended particles. I think that it will be necessary to prove to the judicial authority having that matter in charge that there was absolute danger to life, or some death from such a cause, or that this effect in the harbor was directly traceable to this discharge from the Passaic Valley sewage, as isolated from all the other discharges into the harbor, and I think I have already tried to make perfectly plain the fact that this Upper
2361 Bay of New York Harbor is really the great mixing basin of all this waste discharge practically. My experience has been, and I think it would be extremely difficult to secure such a result. I am doubly sure of that opinion from the fact that that has been the experience quite generally in this county, and noticeably in the case of the Chicago Drainage Canal. After you have got the works going nobody will step in to stop them.

Q. Well, Mr. Fitz Gerald, is it a practical difficulty in your mind to determine whether the pollution of the waters of the bay can be determined to be the resultant of the operation of this sewer, or whether there may be doubt as to whether New York City, the hand

of the complainants in this case, is not itself responsible for the pollution?

A. Yes, that is one of the difficulties.

Q. That may be the difficulty, that New York may be producing such bad results that it would be impossible to say whether New Jersey was contributing to them or not?

A. No, not at all.

Q. That is not it?

A. No.

Q. Then what is it?

A. I misunderstood you. I think New York is undoubtedly contributing to such a result, and I have criticized them very severely for continuing to do so, and I think it is her duty and I now think it is her intention to clean her skirts, and I think it is her duty, therefore, to fight this New Jersey project for the discharge of this large mass of sewage directly into the Upper Bay with all the power she possesses.

Q. You do not profess to be any special expert on intentions?

A. Not at all.

Q. You do not think that your view as to what the intentions of the State of New York may be is entitled to any special
2962 weight as testimony, do you?

A. I do, yes.

Q. Why do you?

A. Because I have had a great deal of experience in these matters all my life.

Q. And thereby you are able to arrive at a determination of what the intention of a sovereign state is?

Mr. O'Sullivan: That is objected to. The psychology of the state is rather too abstract, I think even for this inquiry.

Mr. Riker: Yes, it is when the witness professes to state what the intention of the state is. I want it to appear how absurdly abstract it is.

The Commissioner: Note the objection of counsel for complainants.

The Witness: I do not feel competent to give an answer.

At 1 P. M., adjourned for noon recess until 2 P. M.

2963

CORPORATION COUNSEL'S OFFICE,
NEW YORK, June 20, 1912—2 p. m.

DESMOND FITZGERALD, a witness called on behalf of Complainants, recalled for further cross-examination, testified as follows:

Cross-examination by Mr. Riker (resumed):

Q. You testified on your direct examination to some proposals by Mr. Gray for Paterson?

A. Yes.

Q. And Mr. Hazen?

A. Yes.

Q. How long ago were those proposals made, do you know?
A. Well, early in the history of those cases, and I think I gave the date.

(Witness refers to memorandum.)

A. (Continuing) 1903.
Q. Mr. Gray?
A. Mr. Gray.
Q. And Mr. Allan Hazen?
A. 1906.
Q. Are you aware of the fact that since those proposals and estimates were furnished by those two gentlemen, Paterson has joined in the contract for the construction of the Passaic Valley Sewer?
A. I assumed so.
Q. Without anything more than an assumption?
A. Why, I assumed that that was so from the fact that in this report of the Passaic Valley Sewerage Commission all those towns are mentioned and given as part of the scheme, but I had no separate knowledge.
Q. Do not you know that that was only a plan without having any binding effect upon anyone?
A. No, I did not know it.
Q. You did not know that?
A. No.

2364 Q. You did not know that the carrying of it into execution depended upon the municipalities contracting with the Passaic Valley Sewerage Commissioners for the performance of the work?
A. Certainly, I knew there was nothing final about any scheme of that kind until the contract is signed.
Q. Do you know when the contract was signed?
A. I mean the contracts of construction.
Q. Did you not know that the municipalities had to sign a contract to join in the construction?
A. I did not consider that.
Q. You have not considered it?
A. No.
Q. Do not you know, perhaps you do not know, that Paterson has joined in this contract since the execution of the stipulation which is Complainants' Exhibit No. 135?
A. I was not aware of the fact.
Q. In your direct examination I think you said that in your opinion the construction and operation of the sewer as contemplated would result in a nuisance?
A. Yes.
Q. Now, in what respect would it constitute a nuisance and to whom?
A. I think it would be a nuisance to people who navigate on the waters, and I think it would be a nuisance in giving out bad smells. I think it would be a nuisance in lowering the dissolved oxygen around the shore, where before there was sufficient oxygen to prevent sewage from being a nuisance.

Q. You mean by that that it would reduce the oxygen along the shore to a point where the water would no longer take care of the nuisances created along the shore, is that what you mean?

A. Yes.

Q. You do not mean that it would in itself, without regard to those other nuisances, constitute such a nuisance?

A. No, I do mean in itself also, as I have already testified. This sewage passing under the influence of the winds and the tide, would, I think, in itself, make nuisances in the different parts of
2365 the shore.

Q. Well, as compared with the conditions that have been established in Boston Harbor by those sewers, do you think conditions would be as great or greater in New York Harbor from this sewer?

A. I think they would be much greater here.

Q. You do?

A. Yes, on account of the population and the very different condition of the shores, from what they are in the Boston Harbor.

Q. To the people navigating the Boston Harbor, do the discharges from those sewers constitute a nuisance?

A. I think they are liable to.

Q. You think they are liable to, but do they?

A. I think so.

Q. You think they do?

A. Yes.

Q. And there they create well defined sewage fields?

A. Yes.

Q. Visible to the eye?

A. Yes.

Q. And sleek fields visible to the eye.

A. Yes.

Q. At each one of the outlets of the different sewers?

A. I have not seen them at each of the outlets, but I have seen them.

Q. Well, the ones that you have observed, were they plainly visible to the eye?

A. Yes, very.

Q. So that the discharges contemplated from the Passaic Valley Sewer will constitute, in your judgment, such a nuisance as you have described and you think it would be difficult to demonstrate that the nuisance thus described came from the discharge?

A. I do.

Q. And still you say it is a nuisance?

A. Yes.

Q. Now, from what feature of the discharge, as it is described in the stipulation between the United States and the State of New Jersey and the Passaic Valley Sewerage Commissioners, do you attribute the establishment of such a nuisance in New York
2366 Harbor?

A. The stipulation which allows them to discharge the sewage of Robbins Reef without any other purification than that incident to the subsidence of one hour.

Q. That is not what the discharge is defined to be in this instrument?

A. No.

Q. You do not recall that there will be no visible suspended particles?

A. I recall that provision, yes.

Q. And you recall that there will be no deposits objectionable to the Secretary of War?

A. I recall that perfectly.

Q. And that there will be no odors due to the putrefaction?

A. I recall that perfectly.

Q. And there will be practical absence on the surface of grease or color due to the discharge?

A. Yes.

Q. And that there will be no injury to public health?

A. That also I remember.

Q. And that the purification of the sewage shall be such as to render its discharge into New York Bay harmless to major fish life in the bay?

A. That also I recall.

Q. And you say that kind of a discharge, in your opinion will constitute a nuisance?

A. That, taken in connection with the rest of the document.

Q. Your legal interpretation of the rest of the document that you refer to?

A. My practical interpretation of it.

Q. The document *is* defined, is interpreted by you in accordance with what you believe is the legal effect of it?

A. I do not propose to form any judgment of the legal effect, simply of the engineering effect, and of the practical effect, guided by sound common sense as to what the effect of this discharge will be.

Q. Do you apply sound common sense to the second stipulation, the second paragraph of the stipulation which provides that the Passaic Valley Sewerage Commissioners agree that in the operation of this sewer at all times the following results shall be se-
2367 cured, either by compliance with the requirements of the immediately preceding paragraphs, or through requisite lawful additional arrangements?

A. I applied common sense to that.

Q. Now, applying common sense to that, if the requirements described in the paragraphs, immediately preceding do not produce the result, do not you understand that there will be other additional arrangements introduced which will produce the results?

A. I do not so understand it.

Mr. Riker: You do not so understand it, that is all.

Redirect examination by Mr. O'Sullivan:

Q. What do you understand by that, Mr. FitzGerald.

A. As I said before, I am at a loss to understand what is does

mean, lawful arrangements. It may mean a great many different kinds of things.

Mr. O'Sullivan: That is all. Are you through?

Mr. Riker: Yes, that is all.

EARLE B. PHELPS, a witness called on behalf of Complainants, being duly sworn, testified as follows:

Direct examination by Mr. O'Sullivan:

Q. What is your full name, Professor?

A. Earle B. Phelps.

Q. What is your profession?

A. I am a consulting sanitary engineer, and Professor of Public Health in the United States at the Institute of Technology.

Q. Where did you study for your profession?

A. I studied in the Massachusetts Institute, graduating in 1899, in the Department of Chemistry, and I have continued my studies ever since.

Q. Have you ever — any connection with the Massachusetts State Board of Health?

A. I was employed by the Massachusetts State Board of Health in the capacity of Assistant Bacteriologist at the Lawrence Experiment Station, where investigations on the purification of water and sewage were being carried on. I was there from immediately
2368 following my graduation until early in the year 1903. I was then employed by the Institute of Technology to take charge of similar researches at the Sanitary Research Laboratory, which was at the institute at that time, and I have been associated with that work ever since.

Q. During your work as bacteriologist at the Lawrence Experiment Station, what line of investigations were you engaged in?

A. The investigation of all problems relating to the purification of water and sewage, and allied sanitary matters, such as the effect of water pollution upon shell-fish.

Q. Have you ever taken, or undertaken to make any investigations for the City of Springfield, for instance, as to its water supply?

A. I was sent to the City of Springfield by the State Board of Health and was for one year in charge of the laboratory and of the experimental studies being made there relative to the purification of the water supply of that city.

Q. Now, since 1903 have you been on any sanitary work, and, if so, state what work?

A. Since 1903 I have been connected primarily with the Institute of Technology, and in that connection having charge of the experimental investigations, mainly on sewage disposal. Shortly after that I began to have a private practice, and from that date to this I have continued to enlarge that practice and have had quite a wide experience in the practical applications that I had been studying experimentally.

Q. Just prior to the matter that you were describing, had you any connection with the United States Geological Survey?

A. I was commissioned as Assistant Hydrographer in the United States Geological Survey, beginning about 1904, and I believe my commission is still in force, although not actively.

Q. What line of work?

A. My work for them was special investigations of stream pollution, having reference to the purification and disposal of
2369 various trades wastes. For several years I carried on successive studies in several parts of the country looking to the treatment of trades wastes.

Q. Are you now in private consulting practice as a sanitary engineer, as well as holding your chair in the Massachusetts Institute of Technology?

A. I am.

Q. Now, coming to the year 1910, were you engaged in any special line of investigation relative to our harbor waters?

A. With Col. William M. Black of the United States Army Engineering Corps I was retained by the Board of Estimate of New York City to make a one year's study of the present condition of New York Harbor as regards pollution. Of the possibilities of improving the present condition, and in fact of the general problem of sewage disposal into New York Harbor.

Q. In brief what was the scope of comprehensiveness of the character of this work; what did it involve?

A. Our problem primarily was to determine the capacity of New York Harbor to receive and dispose of sewage. Secondarily, if we found that the capacity was being reached, or would be reached in the future to suggest means whereby present conditions could be improved or the final day of reaching the limit could be postponed. And in the third place, along that same line, to indicate the proper points of discharge for the drainage of the various areas contributing sewage to this region, having reference to the desirability of discharging sewage, if it must be discharged, at those points in the system where it would do the least harm to the whole system.

Q. Have you contributed any to the literature of your profession?

A. I have written quite extensively in the technical journals and the scientific publications upon matters connected with water purification and sewage disposal.

Q. Covering a period of what amount of time?

A. Well, I began my career as *I* writer in 1903, I think.

2370 Q. Prof. Phelps, are you familiar with the waters of New York Bay and its tributaries?

A. I am, quite extensively.

Q. Have you made any studies of the situation in New York Harbor, having reference to the discharge therein of the contributing areas?

A. The studies that I have already referred to with Col. Black.

Q. During the year 1910?

A. Yes, sir.

Q. Well, what did you do in conjunction with Col. Black?

A. I carried on an investigation of the waters of New York Harbor and its tributaries, with reference to the present evidence of

pollution and the present capacity of the harbor to receive and harmlessly dispose of further additions to the sewage. This investigation involved the study of the tidal conditions and currents, of the concentration of sewage in each of the main divisions of these waters, and of the digestive capacity of the harbor waters as a whole, and waters of each of the subdivisions.

Q. What criteria did you take into your consideration in your determination of the degree of the pollution of such a body of water as New York Harbor water is?

A. There are four criteria of pollution which I used, all of which we considered. They are the bacterial condition; second, the condition as evidenced by a sanitary chemical analysis; thirdly, the condition as evidenced by the physical appearance, color and turbidity, and by the physical characteristic of odor, fourth, the condition as evidenced by the amount of dissolved oxygen contained in the waters.

Q. Considering these criteria, which of them in your opinion is of most value in the study of the conditions in a body of water like New York Harbor?

A. The fourth one that I have mentioned, the dissolved oxygen, I consider the only one of real quantitive value. The number of bacteria in a body of water so heavily polluted as is this bay gives us no real quantitive measure of the degree of pollution. It is an excellent and very sensitive test, and in drinking water
2371 supplies is our main reliance. When the water gets beyond a certain degree of pollution, however, additional polution is not indicated by additional bacterial numbers.

Q. Is it correlated with any other visible and physical evidence of pollution?

A. Not quantitively, as these other evidences increase rapidly the numbers of bacteria do not necessarily increase in similar ratio. The second test that I mentioned, the sanitary chemical analysis, so called, is merely the determination of the organic impurities in the water. These impurities may have come from one or another source; they may have been the former constituents of the water; such as the coloring matter of swamp waters, or they may have been derived from sewage. This test, in the absence of anything better, gives a fair quantitative measure of the total impurities in the water, but for purposes of the investigation of New York Harbor, it is not the best criterion. Furthermore, the physical conditions, the appearance, color, turbidity, and odor of the water are of themselves an important and direct means, because they appeal to the physical senses. They are the real things we are combating, yet do not lend themselves to quantitative treatment. I cannot say that a certain color or a cerain turbidity will result because of certain conditions, for we cannot express color and turbidity in terms intelligible to the layman at least. We have a rough quantitative method for measuring these things, but it means almost nothing, even to an expert. We are led then, to the last criterion that I mentioned, the dissolved oxygen. All normal waters contain dissolved oxygen, which is taken up from the atmosphere, just as water dissolves sugar,

if it be added, and there is a limiting amount of oxygen that this water can hold, which we call the saturation value. This cannot be exceeded under existing conditions of temperature and
2372 salinity. If there be in the water also organic impurity, and if bacterial fermentation is taking place, this oxygen is being used up, and a balance is finally struck between the amount present and the amount required for the fermentation, this figure always being lower than the saturation value, and being a very direct measure of the amount of fermenting impurity contained in the water. It is therefore not only the most available criterion of impurity, and the most capable of mathematical treatment and definite calculation, but it is closely correlated with the other things which we are aiming to suppress. The same factors which produce discoloration and bad odors operate also to reduce the dissolved oxygen in the water.

Q. You used the expression "Normal Waters." Will you please explain what you mean by that?

A. I mean waters in Nature.

Q. Well, what I am trying to get at is that oxygen is a component part of the water itself in a certain ratio.

A. I was not speaking of the chemical combination. The ultimate chemical basis of water is oxygen, of course, but dissolved oxygen as distinguished from chemically combined oxygen has the same relation to water as a lump of sugar when it is dissolved in a glass of water. It is in that respect a physical solution. All waters contain dissolved oxygen unless they are badly polluted.

Q. And the oxygen that you have described does not enter into chemical combinations with the water itself?

A. No, it is merely held there.

Q. Now, according to this criterion that you seem to have adopted, how is the capacity of New York Harbor waters to receive sewage limited?

A. If we are to adopt a criterion based upon reduction of the dissolved oxygen from the saturation point, then the amount of sewage or other polluting organic matter which a body of water can receive is determined and limited by the amount of available oxygen which the water can offer for the purposes of oxidation. The sources
2373 of this oxygen in the water originally are several. The first and most important source is the volume of saturated water which comes in from the sea and from the sound at each tide.

Q. I wish you would be more specific as you go along, saturated with what?

A. Saturated with oxygen. I shall use that term, and the term "percent. of saturation" as compared with fully saturated water. A second source of oxygen is what is known as the reaeration by which term we mean the phenomenon of the absorption of oxygen from the atmosphere by the waters. And then, there are physical sources of oxygen in the water, such as the addition through rain and from surface water, and some slight addition possibly from the plankton life, green plants that grow in the water, producing oxygen.

Q. What do you mean by that term "saturation"?

A. The saturation point is all the oxygen that the water can hold. A water is said to be saturated when it has its full quota of oxygen. It is impossible to get any more than that, under most conditions. A supersaturated condition is just possible, but very seldom occurs. If air and pure water are shaken together the water takes a certain amount of oxygen in that way, which is called the saturation amount. Any percentage of that, such as 50 per cent. saturation means that the water has one-half as much oxygen as it can contain as a maximum.

Q. When you use the expression saturated with oxygen of water do you mean 100 per cent?

A. 100 per cent would be the complete saturation.

Q. You have described the sources of the oxygen that comes into our harbor waters?

A. I have just given those.

Q. Yes, and I want to ask you is all the oxygen that comes in from these various sources that you have described available for the oxidation of sewage?

2374 A. No, not at all. If it were all used up the harbor would assume the condition of the Passaic River today. That is, a black, foul smelling stream. The entire exhaustion of the dissolved oxygen is followed in warm weather by the development of extremely offensive odors and by the blackening of the entire liquid. The exact proportion of the oxygen which it is allowable to withdraw for purposes of oxidizing sewage is a matter upon which there is no general concensus of opinion. A correct view can only be had by a study of actual conditions, and a comparison of the analytical determination with the physical conditions observed in each case. I have made careful observations and tests in many places, and have gone into this question of permissible oxygen reduction with a great deal of care. On the basis of the evidence which I have been able to accumulate I have come to believe that a reduction of 30 per cent of the saturation value bringing the water down to 70 per cent of saturation in the summer time, is all that it is safe to permit a body of water such as we are dealing with in New York Harbor. That is, an average figure for the whole body of water, and necessarily there will be variations of considerable magnitude in the various subdivisions of such a body.

Q. How do you account for the variations as to the oxygen percentage in the same body of water at different locations?

A. It is almost impossible to get a uniform admixture of sewage and water. We are trying to mix a large volume of slightly polluted water with hundreds of streams of pure sewage. The result is a sort of marble cake effect, and our sampling indicates that as one of the results.

Q. The conclusion which you have expressed as to the minimum for oxygen percentage in New York Bay, upon what facts and evidence gathered by you do you base that low estimate or high estimate, whichever you regard it?

A. There is evidence, in the first place, that major fish life can-

not exist in water that has gone below 70 per cent. of saturation value.

2375 Q. Does that apply equally to all seasons?

A. That is especially important in the summer time. The Merrimac River at Lawrence is a river which has been subjected to long study, and whose chemical and physical characteristics are well known, and it is a river with which I am personally very familiar. That river, in the summertime, gets down to a point as low as 50 per cent. of saturation, and at such seasons it is distinctly an unclean stream. There is much visible evidence of sewage matter, so much so that bathing in the river is anything but a pleasant operation, and the odors that emanate from it upon a calm evening are such that canoeing and pleasure-boating is distinctly unpleasant. This I regard certainly as below the safe permissible limit, this condition. The condition of the Passaic River, even in the winter time, is too serious to call for any comment. I made an examination of the waters of this river at Newark in the late Fall of 1910, and found there 38 per cent. saturation.

Q. Of oxygen?

A. Of oxygen. The waters of the upper Providence above Fields Point, I have had under observation for a year, and in the warm months, those waters reach a condition of 60 per cent. oxygen saturation. That stream is one that would be characterized by any impartial observer as an unclean stream. It smells bad, even in passing up the river on a large steamer, as I have done. One notices the odors emanating from — stream, and the physical appearance is bad.

Q. Do the physical appearances point distinctly to sewage pollution?

A. They do. On the basis of these observations and similar ones that have not been made with so much definiteness, I am quite convinced that 70 per cent. as an average figure of a large body of water is the lowest permissible limit. Such a limit would mean 50 per cent. in many portions of the waters of the bay.

Q. Now, Prof. Phelps, is the oxygen that is brought into the New York Bay from the ocean and from the Sound available in all parts of the waters of Upper Bay?

2376 A. Unfortunately it is not. The oxygen which is brought into the Upper Bay with each incoming tide is not as thoroughly mixed with the harbor waters so as to be entirely available. In other words much pure water enters both ends of the system, that is at the Narrows and Throggs Neck, and leaves again on the ensuing ebb tide, without having contributed its 30 per cent. oxygen to the work of the harbor. Under ideal conditions the harbor waters would be made to do their maximum amount of work by the discharge of the sewage entering the harbor at the two entrances, namely the Narrows and Throggs Neck. In so far as this ideal condition is departed from, in just so far is the capacity of the harbor, as determined by the total oxygen of the incoming tides, reduced.

Q. Have you investigated the effect of reaeration in its quantitative aspects?

A. Yes, sir; I have.

Q. Will you briefly recount the methods and results of the investigations?

A. When the oxygen of the water has been depressed below the saturation point there is a tendency for a further supply to enter that water from the atmosphere. This phenomenon is known as "reaeration." Much stress has been laid upon the value of this process in the so-called self-purification of water. Its effect is undoubtedly great in running streams and owing to a lack of knowledge of the principles involved, it has been assumed by many that waters like those of New York Harbor were equally subject to this reaerating action. Reaeration may take place by two distinct methods:—Mechanical mixing and by diffusion. In Nature both processes are going on simultaneously. The diffusion process depends upon the tendency of any dissolved substance to pass through the liquid from a point of higher to one of lower concentration. In the case of a body of water we may start with a uniform concentration of 70 per cent. The surface being exposed to the air be-
2377 comes saturated quite rapidly in a thin film. The oxygen then tends to diffuse into the lower layers. The rate of this diffusion is known to follow a well known physical law, one of the factors of which, however, is a constant known as the diffusion coefficient. This coefficient is a measure of the resistance which the water offers to the downward passage of the diffusing substance and varies for each substance, temperature and salinity. By a long series of experiments under exactly controlled laboratory conditions this diffusion coefficient has been determined by me and with this single factor known, I have been able to estimate the amount of diffusion into the waters of the harbor. The rate is so slow that were it not for the other method of mechanical mixing, the whole process would come to a practical standstill in a very few hours, and there would be no material, further increase in the oxygen contained in the water. The mechanical mixing is, therefore, the more important process of the two. This is brought about by the action of tides and currents, vertical eddies, wind and vessels. A careful analysis of all these conditions has enabled me to determine quite closely the total combined effect of diffusion and mechanical mixing in the reaeration of harbor waters.

Q. You mentioned one point there as a qualifying factor. That question of salinity. I would like to ask you in view of that fact whether the body of water that you have examined, namely, the Merrimac River and the Providence River, are they fresh water streams, or are they brackish or salt water?

A. The Merrimac is a fresh water stream. The Providence is a tidal estuary, having approximately the same conditions of salinity as exist in the Hudson River.

Q. Prof. Phelps, will you state what the carrying capacity of fresh water, as against salt water, is? Which can contain the largest amount of oxygen, and in which is the relatively
2378 largest amount of oxygen found?

A. Fresh water.

Q. That is, in normal fresh water or normal salt water, under ordinary atmospheric conditions, which contains the most oxygen?

A. Fresh water dissolves about 15 per cent. more oxygen than pure sea water. About 10 per cent. more than waters of the salinity we have to deal with in the Hudson River.

Q. By any analysis of the conditions that you have described, are you enabled to determine the total combined effect of diffusion and mechanical mixing?

A. These were determined with a very fair degree of precision. The nest result of this investigation was to show that reaeration is an immaterial factor in the present problem. Whereas the total amount of oxygen available for sewage oxidation has been placed at 30 per cent. of the saturation, I find that the actual additions to this quantity of reaeration is less than one-tenth of one per cent.

Q. I wish you would testify a little on that, Prof. Phelps. You say that 30 per cent. is used in the oxidation of organic matter, and the percentage taken in return from the air is how much?

A. One-tenth of one per cent.

Q. Leaving a deficit of how much?

A. The point is this, we are going to allow 30 per cent. of the saturation value for purposes of oxidizing sewage. We will allow our water to go down to 70 per cent. saturation. In addition to that 30 per cent. from the incoming pure water, we have one-tenth of one per cent. saturation, making 30 1/10 per cent. available altogether. I am comparing them in that way so that you may see the relative influences of the two factors.

Q. Now, these other factors that you name, the rain, the rain waters?

A. Those are all minor factors, and are so much smaller in importance, so much less in importance than the reaeration that they may be safely disregarded.

2379 Q. From your studies which you have described in our harbor waters have you arrived at any definite numerical value for the capacity of New York Harbor to receive sewage, as the result of those investigations?

A. That was our chief aim, and by assuming certain ideal cases, it is possible to arrive at a definite numerical value of the capacity of the harbor to receive and digest sewage. I have already stated that the maximum benefit would follow the discharge of the sewage at the two entrances to the harbor. That is at the Narrows and at Throggs Neck, and that discharge would have to be proportioned pro rata to the amount of incoming tidal waters at those two points.

Q. We are assuming this condition.

A. This condition may be assumed as our first approximation, and will at least give us the maximum amount of sewage which the harbor is capable of handling. In a similar way the individual portions of the harbor may be treated separately, and a complete mixing of the sewage added to each area with the incoming waters of that area may be assumed so that maximum values for each of the separate subdivisions may be arrived at.

Q. Have you made a computation on either or both of those bases?

A. I have made a computation on both of these bases. Under the first assumption, namely, that the entire sewage contributed to New York Harbor be collected and discharged at the Narrows or at Throggs Neck, and that the apportionment be pro rata according to the flow of tidal waters at these two points, and with the further assumption that the dissolved oxygen of the waters shall not fall below 70 per cent. of saturation on the average in warm weather, I have estimated that the discharge from 7.4 millions of population could be successfully handled in New York Harbor. This is a maximum figure. In the second instance, I have taken actual populations from the various subdivisions contributing to the harbor and, estimating in the opposite direction, determined the probable effect of the sewage from these populations upon the respective bodies
2380 of water. This computation involves a detailed study of the very complex relations existing between these various bodies. At any one moment the water contained in a given area is made up of water which has existed in various other areas over various tidal periods, and it is necessary to follow out this continuous process of interchange until the ultimate history of all the water in any given area has been determined. With this information in hand, and with a known contributing population to the area in question, the application of the principles already referred to will enable the determination of the exact condition of the water. The results of this computation I have indicated here in tabulated form. That is copied directly from the report.

Cross-examination by Mr. Riker:

Q. What is this table based on?

A. That is the result of the computations I have just been describing. It is based upon all available knowledge of the tidal currents, of the volumes both of the channels and the tidal prisms and the best available knowledge of populations contributing to the various areas.

Q. It is not based upon actual determinations of oxygen in the waters indicated?

A. No, it is entirely a computation. It has not anything to do with actual determinations. It is a computed value. It is the effect which we estimate.

Q. This is a theoretical determination of what the percentage of oxygen should be in the waters, assuming that data which you have assumed?

A. Yes.

Mr. Riker: The table is objected to until such time as the data involved becomes evidential in this case by being proved.

The Commissioner: Note the objection of counsel for defendants.

Direct examination by Mr. O'Sullivan (resumed):

Q. State the contents of that table?

A. The table is as follows, the results of this computation follow:

2381

Area.	Dilution ratio.	Per cent. of oxygen present with Reseration.
Flood:		
A	1	100.
B	1 in 120	75.5
C	1 in 65	54.4
D	1 in 58	48.9
E	1 in 63	53.0
F	1 in 100	70.6
G	1 in 50	40.6
Ebb:		
A	1 in 100	70.6
B	1 in 65	54.4
C	1 in 57	47.9
D	1 in 55	46.0
E	1 in 100	70.6
F	1 in 150	80.5
G	1 in 60	50.6

Q. Directing your atention to area A, what does that refer to?

A. Area "A" refers to the Lower Bay; "B" to the Upper Bay; "C" to the Hudson River, between Battery and 96th Street; "D" to the Hudson River, from 96th Street to Spuyten Duyvil; "E" to the East River, from the Battery to Hell Gate; "F" to the East River, Hell Gate to Throgg's Neck; "G" to Harlem River.

Q. I do not know as I quite understood in your description of reseration what you stated as to the refreshing action of oxygen upon depleted waters, whether it is material in amount or extent?

A. It is quite immaterial.

Q. Have you examined the analytical data that is in evidence in this case?

A. Yes, sir.

Q. Now, does your estimate of the capacity of New York Harbor waters to receive sewage correspond in any way with that data.

Mr. Riker: The question is objected to on the ground that it is in effect a hypothetical question based upon facts which are supposed to be in evidence in this cause, but it is not apparent by the question what matters this witness has in mind making answer to the
2382 question, whether they are in fact matters of proof, legal evidence in the cause or not.

The Commissioner: Note the objection of counsel for defendants.

Q. Prof. Phelps, I hand you complainants' exhibit No. 31 and I hand you complainants' exhibit No. 94, and I hand you complainants' exhibit No. 99 and complainants' exhibit No. 97, and I ask you if they contain the data described as analytical data in my question?

A. They are what I had reference to; yes, sir.

Q. Does it correspond with that?

A. The analytical material coincides in striking manner with the results I have calculated upon a purely theoretical calculation of the conditions. This analytical check upon my computation proves two points. First, the question of the importance of reaeration upon which stress has been laid by writers in this field has been correctly interpreted by my studies; for, if this were not so, the calculated oxygen content of the water would be far below that actually found. In the second place, it is evident that the complex studies of the movements of the harbor water from one area to another have been made with considerable precision, or otherwise the relative oxygen values found by actual test would not agree with the values computed. In only one instance, namely, in the East River, is there any serious discrepancy, the actual values found being 60 per cent, as against 71 per cent, computed. It is obvious either that there is a greater contributing population to these waters than I have allowed, or there is less water reaching the East River from the Sound. The table of values which I computed in 1911, and of the average values of dissolved oxygen which I have now computed from the testimony in this case, I have here.

Q. Referring to what exhibit?

A. The exhibit to which you have just referred. I have appended here in tabular form a summary to show the agreement.

2383 Q. State the contents of that table?

A. That summary is as follows:

Summary.

	End of			
	Ebb tide.		Flood tide.	
Area.	Found.	Calculated.*	Found.	Calculated.*
A	82	70.6	..	100.
B	58	54.4	74	75.5
C-D	50	47.0	64	51.7
E	60	70.6	53	53.0
F	82	80.5	60	70.6

*Black and Phelps, p. 36.

Q. Do your computations show the capacity of New York Harbor waters to receive sewage, and as to whether or not the present amount of sewage discharged into it is excessive?

A. They do. With the limiting value of 70 per cent. of oxygen, which I have adopted, the computations and the actual analytical results show a deficiency in certain areas, notably in the Hudson and East Rivers. This indicates to me that the limit has already been reached in this case, and while the general average of the whole harbor is above our assumed standard, there are local nuisances in

these rivers that have already gone below the limits that I believe safe.

Q. Have you noted and examined the analytical data to which I have just called your attention in the exhibits submitted, Complainants' Exhibits Nos. 94, 31, 99 and 97?

A. I have.

Adjourned to June 21, 1912, at 10:30.

2384 Supreme Court of the United States, October Term, 1911.

THE PEOPLE OF THE STATE OF NEW YORK, Complainants,
against
THE STATE OF NEW JERSEY AND THE PASSAIC VALLEY SEWERAGE COMMISSIONERS, Defendants.

CORPORATION COUNSEL'S OFFICE.
NEW YORK, June 21, 1912—10:30 o'clock a. m.

Before James D. Maher, Esq., Commissioner.

Appearances:

Dr. William J. O'Sullivan, Special Counsel for the People of the State of New York, Complainants;

Adrian Riker, Esq., of Counsel for the Passaic Valley Sewerage Commissioners, Defendants.

Met pursuant to adjournment.

EARLE B. PHELPS, a witness called on behalf of the Complainants, recalled for further examination, testified as follows:

Direct examination by Mr. O'Sullivan (resumed):

Q. Prof. Phelps, directing your attention to the facts and figures set forth in that table which you have just read, were these estimates that you have just testified to as to the capacity of the New York Harbor waters to receive sewage conservatively made?

A. It is necessary in any such computation to make certain assumptions. We assume what might be called ideal conditions.

2385 Now, in making such assumptions such as the assumption that the sewage will be perfectly mixed with the stream of water into which it flows the tendency always is to give estimates of population, the permissible polluting population, higher than any that can be actually checked in practise. In that way any estimates of permissible population contributing sewage to the bay without producing a nuisance will be higher than those that will be permissible under practical conditions, where the ideal assumptions are not fully complied with.

Q. Was this table showing these estimates computed on a basis of those ideal conditions?

A. It is computed upon the assumption that I mentioned, that the sewage entering any point was uniformly diffused through the waters passing by that point.

Q. In your experience is that usually found, that condition?

A. That would be impossible with actual achievement, and the results from the discharge of sewage under practical conditions would be worse than those I have computed.

Q. I wish you would give some more detail relative to that table. Under the head in the first column are the letters A, B, C, D, E, and F, and then there are figures in front of those symbols. Will you please explain what they mean? These areas I think I described yesterday. We might, however, refer to them again, and perhaps I might define those terms once for all. Area A, which I will hereafter call the Lower Bay, refers to that area of the harbor waters included between a line joining Sandy Hook and Coney Island and the Narrows. Area B refers in this table to what I will call the Upper Bay hereafter, and is included between the Narrows and the mouths of the Hudson and East Rivers and the entrance of the Kill van Kull. Area C I will call the Lower Hudson hereafter, and includes the Hudson River from its mouth at the Battery to 96th Street. Area D I will call the Upper Hudson, and refers to the Hudson River from 96th Street to Spuyten Duyvil. Area E I will call the lower East River, and it refers to the East River from its mouth at the Battery to Hell Gate. Area F I will call the upper East River and refers to the East River from Hell Gate to Throggs Neck. I will use two other areas
2386 in this discussion, not included in this table. Area G is the Harlem River and Area K will refer to the Kill van Kull.

Q. Upon what line of investigations or analyses or observations is that table based. State, if you will, the work?

A. It is based on several kinds of information and various kinds of study which I would like to briefly enumerate. In the first place it required a detailed study of the tidal conditions existing in the harbor waters. For information in this matter I turned first to the facts of record in regard to the tidal flows, velocities and volume, as determined by the United States Coast and Geodetic Survey. These are matters of common engineering knowledge.

Q. Were you yourself at any time engaged in geodetic work?

A. No, not in this kind of geodetic work.

Q. I understood you to say yesterday that you were engaged in hydrography?

A. Hydrography. In connection with this study I had made measures of velocities at certain critical points of this bay. These served as checks on the work that we had assumed. The work of the Geodetic Survey, however, is a well established basis for work of this kind, being accepted, and is a matter of common knowledge.

From a study of the velocity of the tidal flow, and from the known fact regarding the extent of the tidal prism, that being the prism of water included between high and low water in any given area, which are matters of common knowledge, it is possible to determine the source of the water in any given area, or, in other

words, its past history for some time back. This kind of information was essential for my further computations. I determined, for example, as an illustration, taking the water of the Lower Bay and referring now to the end of the flood tide in each case, the water of the Lower Bay is found to be made up wholly of water which has come in from outside the limits of that bay, namely from the ocean itself. The water of the Upper Bay is composed of 80 per cent. by volume of water which existed in the Lower Bay on the last previous ebb tide, and of 20 per cent., in round numbers, which came
2387 from the outside ocean. Similarly of the waters found in the lower Hudson at the end of the flood 3 per cent. existed in Lower Bay at the end of the last previous ebb and 97 per cent. existed in the Upper Bay at the end of the last previous ebb. Of the waters in the upper Hudson area 17 per cent. existed in the Upper Bay at the end of the last previous ebb, and 83 per cent. existed in the lower Hudson at the end of the last previous ebb. Of the waters found in the lower East River at the end of the flood 100 per cent. came from the Upper Bay from the last previous ebb. Of the waters found in the upper East River at the end of the flood 7 per cent. were found in the Upper Bay at the end of the last previous ebb. 42 per cent. in the lower East River at the end of the last previous ebb. 50 per cent. in the upper East River at the end of the last previous ebb. That is, that much had returned, and about 1 per cent. came from the Harlem River.

Now, it is necessary to continue this sort of analysis almost ad infinitum. I will take merely one case at the end of the ebb to show how complicated the matter becomes. The waters of the Upper Bay at the end of the ebb are composed by volume of 37 per cent. of water which was in the lower Hudson at the end of the last flood. 13 per cent. of the water which was in the upper Hudson at the end of the last flood. 23 per cent. was in the lower East River at the end of the last flood. 11 per cent. in the Upper East River at the end of the last flood, and 14 per cent. in the Kill van Kull at the end of the last flood. Now, since the waters of the Upper Bay at the end of the flood include 80 per cent. of water which was in the lower Bay at the end of the last previous ebb, and the waters of that bay at the end of the ebb comprise all these various admixtures that I have indicated. That I will not repeat. Then we can continue this analysis, and at the end of one or two circuits over this thing we get an admixture of waters which is exceedingly complicated, but which finally becomes more and more constant as we proceed, until we reach a point in this process where study of further tides
2388 back makes no change in the result. In other words, by this process of analysis we are able to solve this complicated problem of the history of each particle of water indefinitely back.

Knowing then the source of the water existing in any area at any moment, its history in the past, and the amount of sewage entering each of these areas at all times, it is next possible to determine the actual amount of sewage to be found in any given body of water. It is evident that the waters of the lower Hudson, for instance, are not only receiving the sewage from the west part of Manhattan Island and

from the New Jersey shore, but they are receiving sewage from every other part of the harbor waters, almost without exception. They receive the sewage of Long Island City and points beyond there up the Sound. The admixture is so complete that there is, I think, no point in the harbor that does not receive more or less sewage from every other point in the harbor. This being the case, it is necessary to resort to this sort of analysis to determine the actual amount of sewage in any given body of water, and also the age of that sewage.

Q. Now, Prof. Phelps, did you do any laboratory work directly preceding or surrounding the time of the compilation of that tabular matter which you have just read, and if so, state what laboratory work you engaged in relative to sewage and the matters that you have just described?

A. The work which I have just described leads up to a point of determining the actual amount of sewage in the various areas under consideration. It is next necessary to know what the effect of that sewage will be upon the waters. That is, we receive no direct information that is of any value by knowing that there is 2 or 10 per cent. of sewage in a given mixture. The real question is what is the effect of that admixture of sewage upon the waters, and I have employed the oxygen criterion to measure that effect. I desire to express my final results in terms of oxygen in the water. Therefore it is necessary to find a relation existing between sewage in various dilutions, and the final result is expressed in terms of oxygen.

2389 That involves a considerable laboratory study of the properties of sewage in general and sewage of this particular Metropolitan area in particular in reference to their powers to draw oxygen from a stream in which they are diluted. This general problem is one on which I have spent much time, and upon which I had already a considerable knowledge. The problem, however, was made specific in this case by studies carried out at Brooklyn at existing disposal works in the Twenty-second Ward, if I am not mistaken, where, for a period of six months, I had made detailed daily examinations of the sewage, both chemically and with special reference to the power of this sewage to withdraw oxygen from water in various dilutions. On the basis of the Brooklyn experiments, and these were confirmed by considerable experience in other places, notably in Boston and at Providence, where similar work was going on.

Q. Under whose direction?

A. My own. I arrived at a relation which could be expressed mathematically, involving the dilution of sewage in saturated water and the rate of oxygen absorption from that saturated water. This relation is the second essential datum for my computations. I might say also in this connection that sewage itself is a very indefinite term, and, if discussed in terms of volume, it is not comparable in different places, but if the results be referred to in terms of population then we may regard the question of volume entirely. The amount of waste material resulting from a population of 100,000 people, let us say, is a fairly constant thing. The actual amount of sewage which those people produce in volume. There are many other things, such as the tightness of the sewerage system, that enter into that question. In other words, more or less ground water enters

all sewers, and as the sewers are poorly built (or well built) the total volume of sewage per capita varies, but the presence in sewage of organic matter, the thing we are interested in here wholly, is a reasonably constant thing in large cities.

Q. At whose instance did you conduct these investigations that you state occupied about six months?

A. These New York studies?

Q. Yes.

A. That six months' work was part of the year's work that
2390 I have already referred to, undertaken on behalf of the Board of Estimate and Apportionment of New York City in conjunction with Col. Black.

Q. Did you furnish a report to the Board of Estimate and Apportionment on the observations made, the analyses conducted, and the results of that work?

A. I did.

Q. Have you got it with you?

A. I have a copy here.

Q. When did you furnish that report to the Board of Estimate and Apportionment?

A. The report was finally turned in on March 23, 1911. There were, however, preliminary reports which were turned in, on various dates. Shall I read all of those dates?

Q. Yes.

A. On April 22, 1910; on June 17, 1910; July 1, 1910; January 12, 1911; March 9, 1911; and the final report on March 23, 1911.

Q. Who read the proof sheets of this report that you have just handed me?

A. I did in person.

Q. And did you compare them with the original?

A. They were very carefully compared by me.

Q. And with what result?

A. They were corrected, any inaccuracies that were found, so that finally they compared strictly with the original report.

Mr. O'Sullivan: I offer the report just described by this witness and produced by him. I offer it in evidence and ask that it be marked Complainants' Exhibit No. 136 in evidence.

Cross-examination by Mr. Riker:

Q. I observe that this document, Professor, purports to be a report of Col. William M. Black. How much of it is his work and how much of it is yours?

A. Well, it is a little hard to divide the work. The work in the first place was planned by us jointly. Col. Black, through his office assistants, took immediate charge of the current determinations, although I was with that party a good deal. Col. Black is responsible for the method of computing these tidal currents that I have gone through, although I went through all that work at the time, and for the purposes of this case have computed all those figures. I took

immediate charge of all the chemical and analytical work,
2391 and the discussion of the reaeration is entirely my own, having been done previous to the beginning of this work. The conclusions of the report are our joint work and throughout the closest cooperation existed, so that it is almost impossible to say that any particular part is the work of one man.

Q. You would not be willing to give Col. Black credit for any part of this?

A. I am willing to give him full credit.

Q. Who is Col. William M. Black?

A. Col. Black is an officer of the United States Army Engineering Corps.

Q. Was he one of the board that examined into this question of issuing a permit to the Passaic Valley Sewerage Commissioners?

A. I think he was.

Q. Where is the original report.

A. I am unable to say.

Q. Returning to that question of the permit. You know the United States Government issued the permit, don't you?

A. I understand so.

Q. And you do not know where the original report is, you say?

A. This original report?

Q. Yes.

A. Why, the last I saw of it it was handed over officially to the city of New York and I do not know anything about it now.

Mr. O'Sullivan: Counsel for complainants desires to direct Mr. Riker's attention to the very last page of the report offered in evidence, where it bears the certification of the secretary of the Board of Estimate and Apportionment, after comparison with the original report.

Mr. Riker: Counsel for defendants is getting a little tired of his attention being directed. He does not seem to care much about that feature of it. The question is, where is the original report, if this witness knows.

Q. You say you do not know?

A. No, I do not know.

Direct examination by Mr. O'Sullivan (resumed):

Q. In the original report, Prof. Phelps, have you incorporated the results of your examinations of sewage that you have been testifying to?

A. Yes sir.

2392 Q. Have those original determinations been produced by you or have they been proved to your knowledge in this case?

Mr. Riker: The question is objected to. The question of proof is purely a legal one, and does not concern this witness, and he is not qualified or equipped to answer any question relating to the nature of any proof in this case.

The Commissioner: Note the objection of counsel for defendants.

A. I have no information on that.
Q. No information about what?
A. Whether or not that material has been produced in this case.
Q. You know whether you have?
A. I know I have not produced it; yes, sir.
Q. And, so far as you know, do you know whether it has actually been produced?
A. I do not know that.

Mr. Riker: The offer is objected to on the ground that the original report is incompetent for evidential purposes in this case, not being a matter of the witness's knowledge or a recognized standard authority on the subject. It is also objected to on the ground that it is an attempt to make a self-serving document out of a report to a subordinate body of the complainants in this case. It is further objected to on the ground that the matters contained in it, as presented, have not been subjected to cross examination and have not been proved in this case; and this particular offer is further objected to on the ground that it purports only to be a printed copy of an original, which, so far as this witness knows, is within the jurisdiction of the court, and can be produced in this cause. And on the ground that the offer is not properly proved as evidence in this case.
The Commissioner: Note the objection of counsel for defendants.
Received and marked Complainants' Exhibit No. 136.

Direct examination by Mr. O'Sullivan (resumed):

Q. Based on the investigation made by you, which you have just testified to, Prof. Phelps, and on the report founded on and summarizing these investigations, did you make any recommendations to the city of New York relative to the subject matter de-
2393 scribed by you?

Mr. Riker: The question is objected to on the ground that recommendations made to the city of New York are not competent evidence in any case, and do not bind the defendants.
The Commissioner: Note the objection of counsel for defendants.

A. I did.
Q. Will you state what recommendations you made, based on your investigations and report?

Mr. Riker: The same objection.
The Commissioner: Note the objection of counsel for defendants.

A. I found that the capacity of the harbor waters to receive and digest sewage was rapidly being approached, if it had not already been reached. Some measure of relief, therefore, seemed imperative, and the recommendations which were made to the city were based upon a broad consideration of the question from an economic point of view, and in an attempt to disregard political boundaries. If these harbor waters have a definite capacity for sewage digestion and if that capacity is now exceeded, or will become exceeded in a

few years, then it is necessary to apportion among the various contributing populations a definite share of the powers of the harbor to dispose of sewage. If all interests were mutual and common, that appointment would be based upon purely economic principles, upon the principle of applying the greatest relief at the minimum of expense. There would be no question of the respective rights of communities based upon their shore line or their populations or upon their respective drainage areas, or upon any other artificial or topographical boundary, but such an apportionment would be based solely upon the basis of the feasibility of purification in the various areas.

Mr. Riker: I shall move to strike out this question on matters that are not in controversy in this case, all purely hypothetical and not within the knowledge of this expert.

The Commissioner: Note the motion of counsel for defendants.

Mr. Riker: I shall move to strike it out as immaterial to the 2394 issue.

The Commissioner: Note the motion of counsel for defendants.

Q. Prof. Phelps, are you now stating matters relative to the sewage digestive capacity of our harbor waters, and what fraction of that sewage digestive capacity is left or remaining?

A. I am stating rather my line of reasoning upon which recommendations were made to the city.

Q. Relative to the digestive capacity of the harbor waters?

A. Yes, sir.

Q. Proceed.

A. It is almost, if not quite, impossible, in the present state of the art to purify the sewage of Manhattan Island. On the other hand, it is quite simple and readily feasible to purify the sewage on certain parts of Long Island, Brooklyn and Queens. Now, it makes no difference to the waters of the East River whether a million gallons of sewage be added from the east side of Manhattan or from Brooklyn, and just as much good will result from the purification of a million gallons of sewage in Brooklyn as would result from the purification of an equal amount from the east side of Manhattan. But the cost of that treatment in Brooklyn is reasonable, and is such that the project is feasible. The cost of the treatment of the sewage of Manhattan under the present conditions, and with our present knowledge of sewage disposal, is such as to make the project almost, if not quite, impossible. In any event the cost is prohibitive. Therefore, our recommendations to the city were to disregard the political boundaries of the various boroughs and to make this question of harbor purification, harbor cleaning, a matter of the greater city as a whole, and to start at the outskirts. We advised, for instance, that as much as possible of the sewage of Queens be diverted as far to the north and the east as possible, and discharged at a point as near as possible to the Long Island Sound entrance. In a similar way a large section of Brooklyn can be made to drain to the south and discharge into the waters of Jamaica

Bay. Purification works were found necessary in that case and were provided for. The Borough of Richmond, draining largely into the Upper Bay at present, should properly drain into the Lower Bay, pushing the sewage out into the purer waters, where
2395 gradual dilution is possible, and conserving the waters of the Upper Bay and Hudson and East Rivers for the boroughs of Manhattan and the Bronx, where the congested population and the great scarcity and value of land makes purification works impossible. A successful purification of the sewage of Manhattan and the Bronx will be called for, but if they can be postponed for ten years or even five there is every reason to believe that the art of sewage treatment will have progressed to such an extent that it will not be impossible to treat this sewage. Progress has been so rapid in the past, and so much more study is now being given to the question than has ever been given to it in the past, that I have the strongest belief that within a very short time the purification of the sewage of Manhattan will be feasible. Progress has been in the direction of concentrated treatment, of saving in land area. Treating larger volumes of sewage upon the same area, and if progress is continuous in that direction the particular difficulty of this case will be met, the difficulty being that of suitable land area, area of any kind for treatment purposes.

Q. In these recommendations did you make any of them relative to the treatment of the sewage of Manhattan and the Bronx?

Mr. Riker: The same objection.

The Commissioner: Note the objection of counsel for defendants.

A. Only in the general terms that I have indicated, that the time is coming in the not far distant future when the sewage of Manhattan and the Bronx will have to be treated, and the urgent recommendation that the problem be handled along the lines I have indicated. In order that that day may be postponed as far as possible, to take advantage of improved work and improved processes.

Q. And what advantage do you expect will flow from the treatment that you have outlined?

A. The character of the harbor waters would be improved, and could, with the suggestions that I have made, be brought up to the standard I have adopted at the start, 70 per cent of saturation.

2396 Q. Earlier in your testimony you gave the criteria by which you measured the capacity of the New York Harbor waters to receive and digest sewage. Which of those criteria would be most effective under the treatment that you have recommended.

Mr. Riker: The question is objected to on the ground that it is immaterial to this inquiry.

The Commissioner: Note the objection of counsel for defendants.

A. All the criteria would show the result of this treatment, but, most important, the dissolved oxygen, which I pointed out to be the essential thing would be improved.

Q. Prof. Phelps, have you had submitted for consideration the

complainants' exhibits in this case numbering from 1 to 126, inclusive

A. I have.

Q. Have you read the hypothetical question put to Mr. Eddy in this case?

A. I have.

Q. Now, taking all these facts and circumstances of record in this case as recited in that question, and facts observed by you into your full consideration, what in your opinion will be the results of the contemplated discharge from the Passaic Valley Trunk Sewer outlet into New York Upper Bay in the vicinity of Robbins Reef on the harbor waters and tidal waters of New York Harbor, under present existing conditions and under prospective conditions, on or about the year 1940, and during the intervening period between the present year 1912 and the year 1940?

Mr. Riker: The question is objected to on the ground that the hypothesis does not state the evidence upon which this expert is asked to give his expert opinion, and that it does not appear in the question what the basis of his answer may be, and particularly it does not appear either from the exhibits referred to or in any other way in this case what the contemplated discharge from the Passaic Valley Trunk Sewer outlet is, upon which this witness is asked to express an opinion.

The Commissioner: Note the objection of counsel for defendants.

2397 A. The discharge contemplated at this proposed Passaic Valley Sewer will, in my opinion, immediately increase the present evidence of pollution in New York Harbor and reduce the capacity of the harbor to receive and dispose of sewage. By the methods that I have already indicated I have computed the probable effect of this discharge upon the Hudson River.

The location of the outlet with respect to the channel will, in my opinion, cause the major part of the flow to go due north into the Hudson River during flood tides. From a consideration of the tidal volumes and of the tidal prism in the Hudson, I estimate that for six hours out of every thirteen the entire flow of this sewer will go into the Hudson River. The prism between the Battery and 96th Street at the end of the flood is made up wholly of water that has passed directly over Robbins Reef. One-third of this water has passed over the reef three times, and 10 per cent. of it has passed that point five times. This illustrates the accumulating effect of the tidal oscillation by which the direct effect of the sewage discharge is magnified in these tidal estuaries. The Upper Bay is a great mixing basin for all the waters which enter and leave it. It is not possible to state definitely how complete this mixing is. In the absence of any such statement it is not possible to exactly determine the extent of this accumulating action of the tides. I have calculated it, however, upon two extreme assumptions between which the real truth must lie. I assume a complete mixing at each tide and we may assume no mixing whatever. In the first case, the sewage of the Passaic Valley Sewer will, in 1940, have a

dilution in the Hudson River, between the Battery and 96th Street, at the end of the flood tide, equivalent to only six times the dilution that exists there today; or, in other words, the extent of the additional pollution will be 16 per cent. of the present pollution. On the opposite hypothesis and under similar conditions the corresponding value is 8 per cent. Therefore, it may be stated with every degree of fitness that the existing state of pollution in the Hudson River will be increased by this proposed discharge by an amount between 8 and 16 per cent. of its present amount. This means that the capacity of the Hudson River, which is
2398 the weakest point in the entire system, will have been reduced to a dangerous extent. Instead of conserving the waters of this great center of population the proposed sewer project will actually throw an additional burden upon the already overloaded waters of the lower Hudson. In my opinion this question of putrescible organic matter and of the oxygen relations of the stream is of far more importance than any of the criteria which have been suggested in the stipulations with the Federal Government. These refer to visible suspended matter, to the appearance of the water, and to the odors. The sewage as it is discharged may be conceived to produce none of these effects, and yet may rob the lower Hudson River of the oxygen which is absolutely essential to its well being. One of the secondary effects of any such installation will be to force the earlier application of purification to Manhattan sewage. This in turn means less imperfect methods and will involve greater expense.

It is further my opinion that the works proposed will not accomplish the results stipulated.

Q. Proposed by whom?

A. Proposed in the stipulation to which you were referring.

Q. Between the United States Government and the State of New Jersey?

A. Yes, sir. It will not accomplish the results stipulated, nor is it feasible by any practicable plan to bring about those results. The cost of purifying the sewage of the Passaic Valley to the extent indicated in the stipulations would be so great that the entire advantages of the project as a whole would disappear. It is not feasible, therefore, from an engineering standpoint, to produce these stipulated results either by the present plant or by any additions to that plant which may be made in the future. These things are needed, possibly, but they are an exceedingly costly alternative to the simpler problems of individual treatment by the towns.

Mr. O'Sullivan: Your witness.

2399 Cross-examination by Mr. Riker:

Q. Professor, what is the standard of saturation of water with dissolved oxygen?

A. Water can dissolve oxygen to an extent which is fixed, but which varies with the temperature and with the salinity.

Q. Is there no standard by which you work on dissolved oxygen with reference to those two features?

A. I hardly understand what you mean by standards.

Q. You do not know of any standard. You know what the word "standard" means?

A. I understand the word in its general sense.

Q. You do not understand it as used by me in this question?

A. No, sir.

Q. And therefore you cannot answer the question?

A. No sir.

Q. You have testified to an ideal condition of sewage discharge with re-erence to the waters of New York Harbor. Where did you place that sewage discharge?

A. At the entrances, at the Narrows and at Throggs Neck.

Q. Why did not you put the ideal point out in the ocean? Would not that be more ideal?

A. That would be better; yes, sir; that is outside the limits of the harbor, however.

Q. As a matter of fact the further you get it away from the inland waters the better off you are?

A. That is true.

Q. It does not require any expert knowledge to know that does it?

A. No.

Q. Any person with ordinary intelligence would appreciate that probably, would he not?

A. I do not care to say.

Q. Now, you would not want to answer that question. As a matter of fact the nearer the ideal point that you have designated for any particular discharge is located, the better it is, is it not, with reference to the waters of New York Harbor?

A. Yes, sir.

Q. So far as large bodies of sewage are concerned the proposed location of the Passaic Valley Sewer outlet is the best that you know of in the Harbor of New York, is it not?

A. No, not the best. It is not at the Narrows. The Narrows would be a better place.

Mr. Riker: Will the stenographer repeat the question?

2400 (Question repeated by the stenographer.)

A. I have answered that.

Q. Do you know of any other sewer conducting a large body of sewage into the waters of New York Harbor located in any better position than this proposed outlet?

A. No.

Q. It is the best, as a matter of fact, that you know of in actual practice, or in contemplation?

A. Are you talking of the best proposed outlet or the best existing outlet. There is a little confusion between proposed and existing, I think. That does not exist.

Mr. O'Sullivan: The question is objected to as indefinite, the word "where" having no geographical bearing.

The Commissioner: Note the objection of counsel for complainants.

(Question repeated by the stenographer.)

A. I cannot compare them, my one thing is the best that does not exist.

Q. You cannot answer the question as offered?

A. No.

Q. As a matter of fact the sewage of the Greater City of New York is from your point of view discharged in the most objectionable way possible, is it not?

A. Yes.

Q. And the waters in the area which you have arbitrarily designated by letters, but which I think you have described as being included within the mouth of the Hudson, or some point upon the Hudson River are, in your judgment, polluted to a dangerous extent?

A. They are.

Q. And in what does that danger consist?

A. They have reached a condition, measured by the dissolved oxygen, where there are unsightly appearances and odors found to follow.

Q. You do not agree, then, that 50 per cent. of dissolved oxygen is a fair minimum of safety?

A. That I should put as an extreme minimum figure. It is certainly not a fair average for any body of water.

Q. Well, this is a local application, so far as this particular area is concerned. Do you think it is a safe minimum?

A. I would not permit 50 per cent in that whole Hudson River area, in those limits.

2401 Q. What figure would you permit?

A. If it was above 70 per cent. in that area, on the average, it would be 50 per cent. in the slips.

Q. It would?

A. Undoubtedly.

Q. Why?

A. Because the slips are nearer the sources of the sewage.

Q. You are assuming that the sewers will discharge into the slips?

A. The sewage gets into the slips.

Q. I am asking you whether you are assuming that the sewage is discharged into the slips?

A. No, sir; I am assuming the actual conditions.

Q. That if the discharge is out in the deep water there will be no effect at that point?

A. The slips will get the most of it.

Q. Why?

A. Because the incoming tide, the water that fills the slips, runs right by the mouth of the sewer.

Q. The mouth of the sewer is assumed to be in the middle of the river in this hypothesis. Where are you assuming the mouth of the sewers are?

A. I am assuming where they are; I do not give any other assumption.

Q. They are just about as badly placed as it is possible to place them?

A. No, they might be a little worse if they were in the slips.

Q. Are not they in the slips in a great many cases?

A. Yes, sir, I think the sewers of Manhattan, with mighty few exceptions, are at the pier-head lines.

Q. Have you examined them in detail?

A. I have examined them quite in detail, yes.

Q. And you are prepared to go on record as stating that in your opinion, with almost no exceptions, they are at the pierhead line?

A. In a large majority of cases.

Q. What is that large majority?

A. I have not counted the actual locations. I would be willing to say more than 75 per cent. are at the pierhead lines.

Q. How much more than 75 per cent.?

A. I do not know.

Q. Are you willing to say that the 25 per cent. are not in the slips?

A. That is another way of putting it.

Q. Getting that same result, but there is a little difference.

2402 Are you willing to say that 25 per cent. are *I* not located in the slips?

A. I am not willing to say any more than I have.

Q. Now, the oxygen content at the mouths of the Hudson and the East River- appears to be 54 per cent., does it not?

A. Yes, sir, 56 per cent. on the average.

Q. Where do you get your figures of an average of 56?

A. Those are computed averages from the analytical data in evidence.

Q. I show you Complainants' Exhibit No. 133, and draw your attention to the averages at the cross-section at those two points. What are they?

A. That gives 55 here.

Q. And at the East River what?

A. 54.

Q. Where is the average 56?

A. I was speaking of the mouth of the Hudson.

Q. I was asking you about the Hudson and the East Rivers?

A. I did not hear the East River part of it.

(Question repeated by the stenographer as follows):

"Q. Now, the oxygen content at the mouths of the Hudson and the East Rivers appears to be 54 per cent., does it not?"

The Witness: I did not hear the East River part of it.

Q. How far up the Hudson does the average you are testifying to of 56 per cent. extend?

A. That average is based on determinations made at the mouth.

Q. You have not attempted to determine that further up the river?

A. Well, I have not done anything on this, but we have determinations further up you see.

Q. Averages?
A. Yes.
Q. Well, now, taking the averages, as you have them, how far does the average of 56 per cent. extend up the river?
A. It is not possible to say from what is in evidence here. The next station is at Mt. St. Vincent. That has been averaged. That averages for both tides 72 per cent.
Q. Well, from the data before you, so far as your examination has extended, you cannot say how far the average of 56 per cent. extends up the Hudson River?
A. No.
2403 Q. Have you determined what the average oxygen content is in the Harlem River?
A. I would have to give that considerable thought.
Q. I asked you whether you had?
A. No.
Q. It would take some little time to do so?
A. Do you mean to determine it analytically, or to compute it from these tables?
Q. Compute it or determine it in the same way that they have been determined in these other instances that you have testified to.
A. Yes. It would take two or three days to get it analytically.
Q. Can you state from such examinations as you have made of the data furnished to you, in an approximate way, what the oxygen content of the waters in the Harlem River was in 1911?
A. Do you wish an exact average?
Q. No, just approximate.
A. I can size this up by the eye and give you a general idea.
Q. Well, give me that.
A. Some determinations made on July 10 showed an average of, roughly, 40 per cent., I should say.
Q. July 10?
A. July 10, yes.
Q. Any other determinations at that point?
A. There are four pages of that here, they range from 28 per cent. saturation, which is the lowest I see, to 93 per cent., which is the highest. I should say the average of the whole series would not be far from 50 per cent.
Q. In the Harlem River?
A. That is the Harlem River.
Q. How do you account for that determination of over 50 per cent. in the Harlem River according to your theory?
A. That was the first of the flood tide at a station 100 feet of the Spuyten Duyvil Bridge. The waters at that place and time were waters from the Hudson, and were the last waters to come up into the Hudson from the lower Bay. That is about as favorable a circumstance as could be obtained there.
Q. At that point?
A. At that point: yes, sir.
Q. And in the water from which that sample was taken what percentage of it had passed through the area which you have indi-

cated by letters, but which I do not remember, being the area above the mouth of the Hudson, the first area?

A. The lower Hudson River?

2404 Q. Yes.

A. All of that water had passed through that area.

Q. All had passed through that area?

A. Yes.

Q. And the average of the waters at the mouth of that area is about 56 per cent.?

A. Yes.

Q. How do you account for 92 per cent. being reached in the Harlem?

A. Because the variations in these results, from hour to hour, are very great. The character of this water, which we necessarily deal with on the average, varies enormously in average from hour to hour.

Q. In other words, one sample is a very poor basis on which to form a conclusion?

A. One sample is worthless for forming conclusions.

Q. At what place do the succeeding number of samples indicate any worth?

A. The value of the observation increases progressively with the increasing number of samples. I do not know that I could state any exact number where worth begins.

Q. Well, one being worthless, how many would you say would have a value?

A. I think one sample an hour during a full tidal period would be a minimum for one point, and that in the Harlem River one point might be sufficient, so that twelve samples taken over twelve consecutive hours I should place as a minimum for results to be used in computations.

Q. Then you think in making an average you should take as a fair element in the average from the Harlem River determinations, one showing 92 per cent.?

A. If that were one of a series, yes, sir; part of the average.

Q. Where did that practically pure water come from?

A. It came from the Hudson River.

Q. And the waters in the Hudson River came from where?

A. The Upper Bay.

Q. And that is a great mixing basin, according to my understanding of your testimony?

A. Yes.

Q. It must have been very poor mixing in that case?

A. Some good water has got to get by and does get by on every tide.

Q. Some practically saturated water got by, did it not?

A. I would hardly call it practically saturated. 93 per cent. indicates a good deal of sewage.

2405 Q. Why not, is not that practically saturated?

A. No, because that is only 93 per cent. saturated.

Q. Coming back to the standard, have you determined the fresh-

ness or saltness of that water from which that particular sample was taken?

A. That was determined, yes.

Q. Have you it before you?

A. Yes, given in other terms. The per cent. of land water is given.

Q. And the 92 per cent. is 92 per cent. on what basis?

A. That is on the basis of the saturation value for water of that particular salinity and temperature. Those two things always enter into the computation.

Q. You know that, do you?

A. Yes.

Q. Now, Professor, where in this harbor, so far as your acquaintance goes, have you ever taken a sample of water of a similar quality as to salinity and temperature and found a higher oxygen content than 92 per cent., if you have ever done so?

A. Must it be exactly similar in salinity and temperature?

Q. I did not say exactly, I said similar, if it was exactly similar, it would be like?

A. I have taken samples in various parts of Narragansett Bay, well down below the mouth of the Providence River, that have contained more oxygen than that.

Q. How much more?

A. Practically 100 per cent., 98 or 99 per cent.

Q. Well, have you ever taken any samples from the waters that are located, with reference to the land, as the point of taking of this particular sample is in the Harlem River, and found from similar water an oxygen content of 92 per cent?

A. No, I have not.

Q. Would the fact that this water is taken in the Harlem River, without reference to pollution by sewage, be likely to result in the reduction of the oxygen content, or would it not, below the saturation point?

A. I do not understand the question.

2406 Q. Do you think it is possible to obtain a sample of water from a body of water of the character of the Harlem River which would show complete saturation of dissolved oxygen?

A. That would be very rare; it might happen, but I would not expect it.

Q. There are other conditions existing in inland waters besides sewage pollution which tend to reduce the oxygen content, are there not?

A. Not to any appreciable degree, if it were not for the sewage condition about these harbors. If there were no sewage in any of these waters, I would expect that water to be saturated.

Q. You do not think that vegetable matter is capable of reducing the oxygen content of water?

A. Only under peculiar conditions, which could not exist here. A stagnant water, a deep pond, has its oxygen exhausted, but running waters never do, if they are only polluted by natural, normal pollution.

Q. Your judgment is that the oxygen content of a stream like the Harlem River is not subject to being diminished in any way except by sewage pollution?

A. Yes, sir, that is my opinion.

Q. This tidal prism that you have spoken of, that is a well known and recognized subject of investigation, is it not?

A. Yes.

Q. You are not the discoverer of that in any sense?

A. No.

Q. Now, when you have attempted to compute the effect of a discharge at Robbins Reef of the proposed Passaic Valley Sewerage Commissioners Sewer, and have determined the limits to your satisfaction of the effect upon the waters in the area about the mouth of the Hudson River, what kind of a discharge have you based your computation on?

A. Upon the discharge which will result from the treatment of the sewage of 1,600,000 in the way specified in that Federal compact.

Q. And that is in the year 1940, that you are basing it upon?

A. Yes.

Q. You have not made any figure for the present year?

A. I did; I did not testify to them.

Q. They are not as large or imposing as the ones you have testified to?

A. No.

2407 Q. Can you give them?

A. They are practically in proportion to the population. Assuming 700,000 as the present population it would be a little less than one-half of that exactly, seven-sixteenths.

Q. So that your limits would be what of the polluting effect upon the waters of this particular area?

A. About three and one-half to seven per cent. of the present pollution.

Q. And you are not assuming, in your calculation for 1940, that any of these great discoveries in the line of sewage purification will be monopolized by the city of New York, are you?

A. No.

Q. They would probably be equally applicable to sewage from New Jersey?

A. Quite so.

Q. Now, in making these computations, Professor, on the basis that you have testified to, what population have you used as one of the factors in your problem?

A. In the New York problem or this?

Q. This last problem?

A. 1940 population was taken as 1,600,000.

Q. And you have treated that on the basis of the expected sewage from that population?

A. Well, as I explained, I rather eliminated the volume of sewage matter. I treated the population directly.

Q. And having as one of the factors, say, 1,600,000 population about?

A. Yes.

Q. Is that the figure that you have used for your 1940 calculations?

A. I think that was the figure.

(Witness examines memorandum.)

A. (Continuing:) Yes, that was the figure I used.

Q. What allowance did you make as against that figure for the effect of treatment as prescribed in the specifications in the stipulation between the United States and the State of New Jersey and Passaic Valley Sewerage Commissioners?

A. As I am dealing with the question of oxygen I made no allowance whatever.

Q. That treatment described in detail in that stipulation you have examined?

A. Yes, sir.

2408 Q. What result will that have on the sewage so treated with reference to the organic content of the sewage?

A. It will remove some of the suspended organic matter, the coarser matter, not all of it, and none of the finer material and colloidal material, and none of the dissolved matter.

Q. Is or is not the matter which you now say you think will be removed organic and of such a character as to reduce the oxygen content of the water into which it is to be discharged?

A. It is of such a character that the oxygen requisite of a body of sewage—of that kind of material in a body of sewage is extremely small with regard to the whole. The treatment, as a whole, combined with the long passage along the lengths of the sewer, and the age of the sewage, will, I am satisfied, produce a sewage which has a greater oxygen requirement than has the sewage of New York City on a per capita basis. The removal of that will make it better than if no removal were contemplated, but will not make the sewage any better than the fresh sewage of New York as discharged at present.

Q. Now, what actual facts do you base that conclusion on?

A. Certain well known facts in sewage chemistry, which I will explain. The oxygen requirements of a body of sewage, by which I may designate the total amount of oxygen which that body of sewage will eventually consume, if it is diluted in water and allowed to oxidize, is a fixed quantity in any case, but the rate of oxygen consumption may vary according as the conditions of the sewage vary. In the problem before us the rate of oxygen consumption is the more essential factor. If the sewage consumes oxygen within a few tidal periods, it will have been passed out and diluted and passed out through the Narrows. If it consumes oxygen more rapidly, the total consumption of oxygen and the consequent effect upon the harbor will be worse in that period of time. Now, the age of sewage increases the avidity with which it consumes oxygen so that while the ultimate consumption is not increased we perform the consumption in the harbor where it does harm, rather than outside the harbor where there is plenty of oxygen. For that reason old sewage

is worse for the harbor and requires more oxygen for its immediate treatment than fresh sewage.

2409 Q. I understand I think now, Professor, that the difference between fresh sewage and sewage of the age which you have described with reference to the Passaic Valley Sewer discharge, is that one consumes the same amount of oxygen more rapidly than the other. Am I right about that?

A. Yes.

Q. How long does the sewage from the Island of Manhattan remain within the area of the Upper Bay before it actually discharges into the Lower Bay, in your opinion?

A. Well, perhaps an average of three complete tidal periods.

Q. Three tides, that is eighteen hours?

A. No, thirty-six hours; the three complete tides.

Q. What is the average age of the sewage when it is discharged in the waters of the Hudson River from the Island of Manhattan?

A. I will make a computation here and venture a guess. (Witness figures.) I should say the age would vary from nothing up to 30 minutes in the extreme. Possibly the age would be from 15 to 20 minutes.

Q. And what is the age that you compute of the sewage to be discharged from the Passaic Valley Sewerage Commissioners' sewer?

A. From 12 to 15 hours.

Q. When discharged, then, it will not have been as old as the sewage from Manhattan Island, while still within the limits of the Upper Bay?

A. No. I am comparing now Passaic Valley sewage, when actually discharged, with the New York sewage before it gets out.

Q. And having emptied the sewage of New York City, or Manhattan, into the Upper Bay, either directly or indirectly, and it staying there 18 hours, you think that that sewage will not have consumed as much oxygen per unit as the New Jersey sewage will have consumed by the time they are both purified?

A. No. The New Jersey sewage will stay in the harbor an additional period of time after that, and will go on consuming oxygen, but it will start with so much greater an oxygen avidity that it will consume oxygen at an enormously increased rate.

Q. You think, then, Professor, that the treating of the sewage from the Passaic Valley Sewerage Commissioners' sewer will not result in any less damage to the oxygen of the bay than if that sewage had been discharged fresh from the population upon which you

2410 have based your figures, or in other words, that the treatment, removal of part of the organic matter, will not make it any more than equal to fresh sewage from the same population?

A. That is my opinion, yes.

Q. Have you made any observation of sewage of the age of this predicted discharge, proposed discharge, which bears out your conclusions?

A. Yes, sir.

Q. Where?

A. Brooklyn, and at Boston and Providence.

Q. Now, let me see what your examination in Boston was. What determinations did you make at Boston?

A. At Boston I made determinations of the oxygen requirements of sewage that was eight hours old, and of sewage that was sixteen hours old, in addition to four or five hours in the sewers, making perhaps thirteen hours, fourteen hours altogether in the first case and twenty-one hours in the second. Those results are among those that have led me to this opinion. In each case the oxygen, the rate of absorption was increased over the raw sewage, raw sewage in that case being five hours old.

Q. Were these laboratory tests?

A. Yes, made in the laboratory.

Q. You made no tests in the actual discharge of the Boston sewage into the harbor?

A. I cannot make these careful chemical measurements in Boston Bay. They are carried out under controllable conditions.

Q. And these carefully controlled conditions under which you have made your investigations, do they exist in actual fact in the waters of Boston Harbor and New York Harbor?

A. They do, all except for my test reagents, and so forth. The conditions are present.

Q. So that, in making computations you have assumed that notwithstanding any of the stipulations contained in the general stipulation between the United States and the State of New Jersey there is fairly to be assumed that the discharge from the Passaic Valley sewer will be equivalent to a discharge of fresh sewage from an equal number of inhabitants?

A. Equivalent in the sense of oxygen requirements, yes, sir.

Q. What did you say, in your opinion, the minimum of oxygen content was for the support of major fish life in water?

A. About 70 per cent.

2411 Q. Then, if the purification of the Passaic Valley sewage is such as to render its discharge into New York Bay harmless to major fish life in the bay, does that have any influence upon your computations and conclusions?

A. If that result could be obtained, and if that expression, which is capable of a double meaning, be interpreted to mean that under present conditions, with the sewage now in there, if the addition of the Passaic Valley sewage shall not bring about a condition of under 70 per cent., if this be true that that can be done, then it would alter my conclusions.

Q. Your doubt is as to the proper meaning of that paragraph in the stipulation, is it?

A. I have two doubts. I doubt in my own mind as to how that is to be interpreted, and I have a very serious doubt about accomplishing this result, because we have already, if I remember, about 75 per cent. there, and it would not take much more sewage to reduce that below 70 per cent.

Q. Well, upon the assumption that the paragraph means what it appears to mean your conclusion will be altered, will it not?

A. I say it appears to mean two different things. If you make one assumption I would be glad to answer it.

Q. You have a difficulty with this stipulation similar to Mr. FitzGerald's, in interpreting it to your own satisfaction?

A. This particular clause here I cannot interpret.

Q. I will read it: "The purification of the Passaic Valley sewage will be such as to render its discharge into New York Bay harmless to major fish life in the bay." After hearing it read, have you any question that it means the bay as it is?

A. I do not see that wording here.

Q. The seventh stipulation provides that the purification of the Passaic Valley sewage shall be such as to render its discharge into New York Bay harmless to major fish life in the bay. Is not that before you?

A. It does not agree with what I have before me. Perhaps I have not a proper copy.

Q. Take it this way: "The absence of reduction in the dissolved oxygen contents of the waters of New York Bay, resulting
2412 from the discharge of Passaic Valley sewage, to such an extent as to interfere with major fish life." Do you doubt but what that means the waters as they are, take it that way?

A. Now, the question is?

Q. Will that in any way affect your conclusions as to the effect of the discharge of sewage from the Passaic Valley sewer?

A. Yes, it would.

Q. To what xtent?

A. This would mean practically perfect purification.

Q. It would mean practically perfect purification?

A. Yes, sir. If we have 75 per cent. saturation and we are permitted to go down to 70 per cent., it leaves 5 per cent. available for the Passaic Valley discharge. Now, any treatment that would bring that sewage down to any such condition that it would only take up five per cent. of the oxygen, that would be practically perfect purification.

Q. And in that conclusion your figure of 70 per cent. as the safe margin for fish life is a correct one?

A. Yes.

Q. Is that accepted?

A. Yes, I think so.

Q. By whom?

A. By the United States Fish Commission. That is where I got the information.

Q. That is what you understand to be meant by this stipulation, is it?

A. Yes, sir.

Q. 70 per cent.?

A. Yes.

Q. Is it impossible to produce an effluent of that purity?

A. No.

Q. Is that the effluent that you are contemplating for Manhattan

Island under the ideal conditions which you think may exist in five years from now?

A. No.

Q. What are you contemplating?

A. Nothing as good as that.

Q. What are you contemplating?

A. If we can get rid of two-thirds of the oxygen requirements of the sewage of Manhattan and other tributary areas, I think all requirements will be satisfied for a long while.

Q. And then it will not require practical purity of the effluent from Passaic Valley Sewer to arrive at the results which are stipulated here?

A. No, you assume present conditions in your question.

Q. I am assuming the present conditions; I am also con-
2413 sidering with your assumption, future conditions, so that the ability of the Passaic Valley Sewerage Commissioners and the State of New Jersey to perform their stipulation, in your judgment, depends on whether or not the City of New York is allowed to further continue its pollution of the waters of the bay and to increase it?

A. That would affect this particular stipulation materially.

Q. Now, in the area which I have directed your attention to once or twice, being the first area of the Hudson River above its mouth, what is there on the west bank of that area?

A. Jersey City, and I think Hoboken. I am not certain—Bayonne.

Q. Do you think Bayonne is there also?

A. I am not certain just where the lines divide Jersey City from Bayonne or Jersey City from Hoboken.

Q. How much population is on that side, do you know?

A. I have not that exactly in mind, possibly 2,000,000 people.

Q. And on the west side of the Hudson River?

A. Perhaps I had better look that up.

Q. I guess you had.

A. I do not find any information on that directly, and I really do not know.

Q. Have you ever been over there?

A. Oh, yes.

Q. Do you think there are 2,000 inhabitants over there?

A. Perhaps that is high.

Q. As compared with the east side, how many?

A. Very much less.

Q. Can you form a working guess as to the proportion?

A. That is just another way of guessing at the other population. I suppose Jersey City has 400,000 people, perhaps.

Q. I think you are over the mark?

A. I will stop guessing then.

Q. There are a good many more on the Manhattan side than there are on the Jersey side?

A. Very many more; yes, sir.

Q. And the discharge of the sewage from those many more on

the Manhattan side is responsible for the large percentage of loss in dissolved oxygen in that water area?

A. Yes.

Q. You testified to something with reference to the feasi-
2414 bility of these municipalities instituting and operating independent purification plants, do you remember that?

A. Yes, sir.

Q. You do not profess to be in a position to advise them on those features, or the advisability of such installation rather than in one general installation at the Meadows?

A. I think I may claim to be in that position; yes, sir.

Q. And on the economic side as well as on the purely technical professional side?

A. The economic side is the essential part of engineering.

Q. Well, the economic side deals with the cost of the enterprise?

A. Yes.

Q. Your opinion would be that it would be better for them to install independent plants and discharge the effluents into the stream from the near neighborhood rather than to conduct the sewage to the proposed purification plants on the Meadows and purify it there?

A. To the extent that it will come up to these specifications here, yes.

Q. Well, the effluents from the local plants are not below those standards, are they?

A. No.

Q. They ought to be rather higher than that, ought they not?

A. These are pretty good standards.

Q. Those were devised by your friend, Col. Black?

A. I think they were. I think those would be satisfactory for all the communities in the Passaic Valley, although each problem is a local one, and I would not want to be too sure of that.

Q. And have you ever suggested to the authorities of the city of New York or this board that you say you made a report to, that they should adopt standards equal to those contained in this stipulation?

A. No.

Q. You never suggested that?

A. No.

Q. Why did you not suggest something of that sort?

A. Because it would be absolutely impossible.

Q. Why impossible?

A. Why, the standard—we are speaking now of the specifications——

2415 Q. They describe this proposed effluent?

A. Yes. To produce such an effluent in any of the territory contributing sewage to this water area, with the possible exception of some of the outlying regions of Long Island, would be practically impossible with present engineering knowledge of the subject.

Q. Is it impossible to produce an effluent which, when discharged into the waters of the Upper Bay, assuming that they are restored

to their normal oxygen content, that these suspended particles will not be visible?

A. Yes.

Q. Practically impossible to do that? Why?

A. There is not any place to put such works. Such works would be very elaborate affairs; would require acres of land on Manhattan Island.

Q. Have you ever been over the Newark Meadows?

A. Yes.

Q. There are acres of land there?

A. Lots of them.

Q. Available for such a plant?

A. Lots of them.

Q. Then, so far as the Island of Manhattan is concerned it is again the economic reason?

A. It is entirely a matter of cost. You can do anything if you have got enough money. You can send it up in balloons.

Q. And is there any difficulty in producing an effluent from which there will be absence of deposits objectionable to the Secretary of War in the Bay of New York coming from the Passaic Valley sewage?

A. I take that to mean——

Mr. O'Sullivan: The question is objected to on the ground that it calls for a strange intuitive knowledge on the part of this witness to define the physchic processes of the Secretary of War.

The Commissioner: Note the objection of counsel for complainants.

Q. That may be a good objection. Put it this way. Is it not possible to produce an effluent the deposits from which in New York Bay will be practically imperceptible?

A. Still referring to New York City?

Q. Yes, referring to any of the communities discharging into New York Bay?

A. The possibility or feasibility of this project depends en-
2416 tirely on geographical location. I believe you started this line of discussion referring to New York and then we got over to the Newark Meadows.

Q. I am asking you whether there is any impracticability in doing it for any community located either in the Passaic Valley or on New York Bay?

A. It can be done in New Jersey quite readily.

Q. Can it be done in New York?

A. I should think not.

Q. Why not?

A. For the same reason that I have given. It would require very extensive land areas.

Q. Too much money?

A. Too much money, yes.

Q. It, in your opinion, is somewhat equivalent to carrying it up in balloons, I think you said?

A. I think that would be quite a reasonable alternative.

Q. Suppose it is conducted in the way that the Passaic Valley Sewerage Commissioners propose to conduct it, to some point of Long Island where there is plenty of land. Any difficulty about that?

A. The cost of such a project I think has been determined. I have forgotten the figures but they are beyond the limit of consideration.

Q. Then, except in the event of the hope for improvement in the science of purification, there is but very little hope of the City of New York getting its sewage out of the bay, in your opinion?

A. Yes, under present methods.

Q. And so, in your opinion, it becomes very desirable from New York's point of view, to prevent anybody from discharging sewage into New York Bay which will exhaust the possibilities of consumption by New York of the dissolved oxygen in it?

A. That would naturally be the attitude.

Q. And from that point of view, of course, the discharge from the Passaic Valley Sewerage Commissioners' sewer, if it conformed to the standards set up in this stipulation, would be objectionable, would it not?

A. No. I already stated that if it did not reduce the dissolved oxygen at Robbins Reef to below 70 per cent. it would be a pretty good effluent, and I think would produce no harm anywhere.

2417 Q. I know, but as the population of New York City increases, Professor, it is likely that sewage from that population itself will reduce the dissolved oxygen in the Upper Bay below 70 per cent?

A. Yes.

Q. And each small fraction of diminution caused by these poor neighboring communities would be objectionable in that it was taking something that hungry New York might need later on?

A. I am allowing you no margin to conform to this stipulation. You would have to produce an effluent that would require no oxygen, and therefore it would do no harm no matter what was done by the city of New York.

Q. You are not even giving us the benefit of the narrow 2 or 4 or 8 per cent. that the average determinations show?

A. I think that will be quite exhausted in a very few years.

Q. Is it not exhausted now; was it not exhausted at the time this stipulation was made?

A. It is going down each year. It will be exhausted before the Passaic Valley Sewer is in operation.

Q. And you think that, in the absence of these advances in the science, under the conditions that exist. New York City will itself have rendered the waters of the Bay of New York unfit to surround a great city?

A. With the small additions to help from the other surrounding communities, that is my belief, yes. In fact I think that condition is practically reached today.

Q. I would ask you now to assume that on the shores of the neighboring state with which you are familiar?

A. Yes.

Q. (There should grow a large population) which should sewer directly into the waters of New York Bay, what then would be the condition?

A. Assuming that New York City does nothing in the meantime the conditions would be more objectionable.

Q. I take it from your statements in regard to your apportionment of sewage capacity, and the cost to New York of doing anything except discharging crude sewage, that you are not disposed to admit any right in the State of New Jersey to discharge sewage into the Bay of New York?

2418 Mr. O'Sullivan: That question is objected to. It calls for a legal interpretation in the part of this witness which he is not qualified to give.

The Commissioner: Note the objection of counsel for complainants.

A. I have not gone into the question of legal rights, and know nothing about them, but it seems to me it is the privilege of an engineer to consider the entire matter economically as I have tried to do. For, in my consideration I have wiped out all political boundaries, and assumed that legal matters could be arranged according to the advice of the engineers. Such an arrangement, in my mind, would involve the subdivision of the entire area tributary to this harbor under a proper supervision and a scientific study of the problem made in the interests of the entire community, and the division of the capacity of the harbor in such a way as to best conserve the interests of the entire community, and protect the harbor at a minimum of expense. That would necessarily involve leaving Manhattan to the last. Jersey's interests in Manhattan are just as great as Brooklyn's, understand, and the most economical way to treat the problem is to push the sewage outside of the area, instead of bringing it to the center.

Q. That is to say, New Jersey's interest in Manhattan is just as great as Brooklyn's.

A. I believe so.

Q. You think Manhattan contributes taxes to pay the expense of disposing of Sewage in Jersey?

A. I think it should.

Q. Is it your understanding that it does?

A. It does not, no.

Q. And your scheme, as I understand you now, your scheme which is the final word from your investigation, is that Manhattan should be allowed to discharge directly into the waters of New York Bay, and that New Jersey should be put to the expense of disposing of and purifying its sewage and keeping out of New York Bay?

A. Which expense would be borne equally by the whole district, including Manhattan.

2419 Q. Then your whole conclusion is based on the assumption of obliterating the lines of division between the separate sovereignties of New Jersey and New York?

A. That would be a strictly engineering solution of the problem; yes, sir.

Q. Now, Professor, beyond this question of the destruction of major fish life by the reduction of the oxygen content below 70 per cent., what are the dangers from such a reduction?

A. The chief danger, if it may be called, is the danger, the chief danger in my mind is the fact that a pure body of water is rendered impure, visibly so, and is so to the sense of smell. This great commercial center of the new world depends upon the harbor as the very heart of its activity, and it seems to me the most serious matter is the fact that this harbor is being destroyed and will, if nothing is done, reach a condition which is best exemplified in that of the Passaic River, a black, foul smelling body of water.

Q. It is being destroyed I think you said?

A. Yes, sir.

Q. The Upper Bay is being destroyed?

A. Yes, sir.

Q. How far has that destruction progressed; in what respects do you think that the Upper Bay has been destroyed?

A. Destruction will be the final consummation of the process. The process is going on now. I would hardly say the Lower Bay had been destroyed today.

Q. Well, what is the process that you are observing that you think constitutes such a destruction?

A. The greatly decreased dissolved oxygen year by year.

Q. In what particular, in your judgment, is an oxygen content in the Upper Bay of 100 per cent. of any greater value than an oxygen content of 75 per cent?

A. It is of greater value because it shows the greater resource; shows that we are not nearly down to the danger line.

Q. It shows that you can discharge more sewage into it?

A. That is it exactly.

Q. Is it valuable in any other respect that you know of?

3320 A. Why, water which is 100 per cent. saturated is a stream of pure clear water. Water which is 75 per cent. saturated has already lost much of its attractiveness.

Q. In what way?

A. Visibly.

Q. You think in that water there is a visible difference?

A. Yes.

Q. In what particulars do you think that visible difference will be demonstrated?

A. Discoloration, turbidity, some odor.

Q. Some odor in what position of the observer?

A. Sailing on a boat on a calm evening.

Q. Well in any other respect?

A. I have not referred to the possible effect upon the health of those dwelling upon the shores. I do not know that I am very competent to refer to that. There is a danger to bathers, but I suppose bathing could be prohibited. There is some danger to those using shell-fish taken from these waters. Probably that could be

prohibited, and it would be economical to prohibit that if that were the only reason for purifying the water.

Q. Anything else?

A. I think that covers the list.

Q. Now, if in that water there is an absence of visible suspended particles, I mean when it is reduced to 75 per cent., would that obviate one of your objections?

A. Yes.

Q. And if there is an absence of odors, would that remove another one of your objections?

A. It would.

Q. And if there is an absence of grease or color, that would serve to assist in removing one of your objections?

A. Yes.

Q. And if there is no injury resulting from the reduction to the public health, that would remove one of your supposed objections?

A. Yes.

Q. Do you recognize those suppositions as being based upon the stipulation between the United States and the State of New Jersey?

A. I recognize them, yes, sir.

Q. With reference to the discharge from the Passaic Valley Sewer?

A. I have already stated if those were performed faith-
2421 fully the discharge would be unobjectionable.

Q. Perhaps I misunderstood you. I understood you to say that all those things might be accomplished and still the sewage discharge might be objectionable. Did you say that?

A. If I did, it was in a slightly misleading way. Rather in a hypothetical way. What I wish to say is that those things cannot be accomplished aside from an improvement in the oxygen conditions, which would make the entire process one which is satisfactory. What I possibly said was that if those things fairly were accomplished, if that could be produced, and no further improvement given o the oxygen characteristics of the sewage than I expect to be given by the proposed works, then, I mean, the thing would not have been accomplished.

Q. That was the hypothesis that these things might be accomplished without improving the oxygen result?

A. Yes.

Q. Do not you think they could be accomplished?

A. I do not. I do not think the whole thing would go together.

Q. Then the unobjectionable character of the discharge as contemplated in this stipulation does not depend alone on the seventh item or clause of the stipulation with reference to that matter?

A. Not wholly, although I think that is the most important clause.

Q. Do you think that these other clauses, which I have drawn your attention to, could by any possibility be complied with without substantially complying with the seventh stipulation?

A. It would be difficult to comply with all the other six and not comply with the seventh, but it might possibly be done. It might be done by processes with which we are not familiar today.

Q. There are no processes that you know of which would accomplish the other stipulations and which would not also accomplish the seventh?

A. I can hardly conceive of any.

Q. So that when you testify to an injurious result from the contemplated discharge from the Passaic Valley Trunk Sewer,
2422 did you have in mind these specifications as describing the contemplated discharge?

A. I was not guided by those in my opinion as to what would follow the discharge of that sewage.

Q. But you were asked in the hypothetical question this: Taking all these facts and circumstances of record in this case and things observed by you into your full consideration, what in your opinion will be the result of the contemplated discharge from the Passaic Valley Trunk Sewer outlet into New York Upper Bay?

A. Yes.

Q. Do you you understand that the contemplated discharge is the one that is described in this stipulation between the United States and the State of New Jersey and the Passaic Valley Sewerage Commissioners?

A. There are two different things described in this document. The contemplated discharge, as I understand it, is the discharge which will follow from the proposed works, which are specifically described in detail. The effluent which is described in the seventh stipulation, in my mind, bears no relation to the specifications for works whatever. These works will not produce this effluent.

Q. The works that you are referring to—you have the stipulation before you?

A. Yes.

Q. They are described in detail in the first general paragraph of the stipulation, are they not?

A. The paragraph A.

Q. Well, the first general clause covers the proposed work. There are subdivisions A and B and C?

A. Yes.

Q. That describes in detail the proposed works that you refer to?

A. Yes.

Q. That is the thing that you had in mind as determining the contemplated discharge as to which you were interrogated in this hypothetical question?

A. Yes.

Q. Well, now, did you have in mind the second general clause of the stipulation to the effect that the Passaic Valley Sewerage Commissioners further agree with the United States that in the operation of said sewer system at all times the following results shall
2423 be secured, either through compliance with the requirements of the immediately preceding paragraphs, or through requisite lawful additional arrangements?

A. I had that in mind.

Q. Do not you understand that the second general clause in this

stipulation is the one which describes the contemplated discharge from this sewer?

A. I do not so regard it, no.

Q. Where else in this stipulation is there any description or specification or stipulation with regard to the character of the discharge, except in the second clause?

A. Nowhere.

Q. So that it does in fact describe the contemplated discharge?

A. It describes it, yes, a certain character of effluent. To say that that is contemplated, however, is not in accordance with my opinion.

Q. Are you going back of the instrument itself and trying to figure on something else that is not embodied in the instrument?

A. The instrument provides definite works. These are the things that can be constructed definitely according to the specifications. Now, from these works, which may be built in the future, will flow an effluent. It is a matter of engineering opinion as to what kind of an effluent will flow from these works. My opinion is that this kind of an effluent will not flow from those works.

Q. That is your opinion, that that will not flow from the works constructed in compliance with the requirements of paragraph 1?

A. Yes, sir.

Q. Is it your opinion that it will not flow from other requisite lawful additional arrangements?

A. I do not know anything about that kind of arrangement for sewage treatment.

Q. You do not know of any other devices or methods which can be applied practically toward producing the effluent that is described, with the exception of those contained in paragraph 1?

A. I do not know what would be lawful under those circumstances, for instance.

Q. You are again troubled as to the distinction between "legal" and "lawful" are you?

A. No, I am speaking of lawful requirements.

Q. Lawful additional arrangements. What did you un-
2424 derstand when you testified in regard to the contemplated effluent. What do you understand by arrangements?

A. That might mean some additional contract by which these specifications were altered. I should call that a lawful arrangement. New Jersey might make a further agreement with all other parties to this suit, and that would be a lawful arrangement.

Q. Now, Prof. Phelps, assuming that the legal intent of the instrument is that the Passaic Valley Sewerage Commissioners agree to produce the results in the effluent which are specified in the stipulations, either through the methods and appliances specifically described in the instrument, or stipulations, or by adopting other methods or appliances or devices for purification of the sewage, then do you say that the discharge contemplated will be injurious to the waters of New York Bay?

A. If they discharge an effluent which comes up to the stipulations I believe that effluent will be unobjectionable in the waters of New York Bay.

Mr. O'Sullivan: Is it feasible to discharge such an effluent in your opinion?

The Witness: I think not.

Q. Why not?

A. Because the cost of producing such an effluent adds to the cost of the sewer so much that it would disrupt the organization. Local purification would be adopted in preference.

Q. You think the municipalities which are concerned in this plan would find it more economical to adopt independent plans, and that is the only reason you can say?

A. No, that is not the only reason.

Q. What other reason?

A. I do not know about the cost of those works; I have not gone into it in detail, but if those specifications are followed literally, the cost of the works would be so great in my opinion that from a financial standpoint and from a political standpoint, it would be unfeasible. They could not ever do it.

Q. Is the effluent more exacting in character than what should be required for the discharge into the fresh streams on which
2425 these municipalities, or some of them, are located?

A. Yes.

Q. Far more?

A. Yes.

Q. More exacting?

A. Yes.

Q. Than should be required of an effluent into the Passaic River?

A. I will not say into the Passaic River. You said some of the streams. Many of the smaller towns could satisfy the requirements with less exacting specifications than these.

Q. Which ones?

A. Bloomfield, Montclair.

Q. Where will they discharge?

A. I think there is a project to take the effluent to the Hackensack River for the reason that the Hackensack River has a greater capacity.

Q. There is a project. You do not know that the project that they have under consideration involves the discharge of the effluent into the Second River?

A. I do not know that; I have heard it.

Q. You would not now attempt to locate the disposal plant within the limits of the town of Bloomfield?

A. I have heard that.

Q. If they do that where will the effluent be discharged?

A. I do not know.

Q. You are not very familiar with that location?

A. I do not know exactly.

Q. Do you know anything about the Second River?

A. No.

Q. You do not even know it is a tributary of the Passaic River?

A. No, I never saw or heard of it.

Q. What other of the municipalities did you think ought not to adopt as exacting a standard of effluent as the one that is described?

A. The specification that there will be absence of visible suspended matter is an extremely severe one. I would not draw any such specification for the city of Passaic. I might for the city of Paterson.

Q. Is that the specification as you read it?

A. There will be an absence in New York Bay of visible suspended particles, yes.

2426 Q. That is the stipulation, that there shall be absence in the effluent itself of visible suspended particles?

A. Yes, if there are to be none in the bay there will be none in the effluent.

Q. Discharged at a depth of 40 feet you think one is equivalent to the other?

A. Exactly.

Mr. Riker: That is all.

Adjourned to June 25, 1912, at 10.30 A. M.

Supreme Court of the United States, October Term, 1911.

THE PEOPLE OF THE STATE OF NEW YORK, Complainants,
against
STATE OF NEW JERSEY AND PASSAIC VALLEY SEWERAGE COMMISSIONERS, Defendants.

CORPORATION COUNSEL'S OFFICE,
NEW YORK, June 25, 1912—10.30 o'clock a. m.

Before James D. Maher, Esq., Commissioner.

Appearances:

Dr. William J. O'Sullivan, Special Counsel for the People of the State of New York, Complainants.

Adrian Riker, Esq., of Counsel for the Passaic Valley Sewerage Commissioners, Defendants.

(Met pursuant to adjournment.)

2427 CHARLES-EDWARD AMORY WINSLOW, a witness called on behalf of Complainants, being first duly sworn, testified as follows:

Direct examination by Mr. O'Sullivan:

Q. What is your full name?

A. Charles-Edward Amory Winslow.

Q. What is your vocation?

A. I am a teacher and consulting expert on sanitary science.

Q. Now, will you state your full training, experience and qualifications, Professor, without going into each in detail by way of questions?

A. I am Associate Professor of Biology, College of the City of New York, Curator of Public Health, Museum of Natural History, and Lecturer in Municipal Sanitation at Columbia University.

I was graduated from the Massachusetts Institute of Technology in 1898 and took the degree of Master of Science in 1899; acted as Assistant Health Officer of the Town of Montclair, New Jersey, in the year 1898, and as Assistant in the engineer's office of the Massachusetts State Board of Health during the summers of 1899-1902.

I taught biology and sanitary science at the Massachusetts Institute of Technology from 1900 to 1910, and was biologist in charge of the Sanitary Research Laboratory and sewage experiment station of the institute from 1903 to 1910.

I was assistant Professor of Bacteriology at the University of Chicago during the Winter term of 1910 and have held my present position since the Fall of 1910.

My experience includes extensive investigations covering seven years on the discharge of sewage into Boston Harbor and practical methods of purification of sewage, particularly with a view to doing away with the offensive condition now produced in Boston Harbor by the discharge of crude and sedimented sewage. In the course of these investigations I had charge of the expenditure of $40,000 for experimental purposes. I was associated with Dr. G. W.
2428 Field in his studies of the relative effect of discharging sewage into fresh, salt and brackish waters in connection with the construction of the Charles River Dam and Basin.

I was associated with Mr. John R. Freeman in his report on the pollution of the Mystic River and its tributaries.

While in the employ of the Massachusetts State Board of Health I made an extensive examination of the condition produced by the discharge of sewage into fresh and salt water, becoming familiar with varying degrees of sewage pollution in such rivers as the Neponset, Nashua, Charles, Ten Mile, Merrimac, Connecticut, Inaboag, Miller's, Westfield, and Ware, and with the effects of discharge into tide water at Lynn, New Bedford, and other seaport towns.

I have been called in to give expert advice in regard to water pollution by a number of cities and towns, including New Bedford, Mass., Hartford, Conn., Newport, R. I., Auburn and Straatsburg, N. Y.; the cities of Montreal and St. Johns, N. B., and the Province of Quebec, Canada.

I was called in by the city of Chicago to study the problem of the purification of the water of Bubbly Creek and to give testimony in the suit between the City and the Union Stock Yards in regard to it.

I made a study of the pollution of the Rockaway River and gave testimony for the city of Jersey City in the two suits between that city and the East Jersey Water Company.

I am a Fellow of the American Association for the Advancement of Science and the New York Academy of Sciences, Vice-president of the Society of American Bacteriologists and a member of the American Public Health Association, New England Water Works Association, Society for Experimental Biology and many other technical societies.

I am the author of text-books on Water Bacteriology (with Prof. Prescott of the Massachusetts Institute of Technology) on Industrial Microscopy and on Sewage Disposal, in collaboration with the late Prof. Kinnecutt of Worcester, and Mr. R. W. Pratt, Engineer of the State Board of Health of Ohio), besides numerous articles in
2429 the Technical Press on the Bacteriology of Water, Ice and Sewer Air, and on the purification of city sewage. The book on sewage disposal is a work of 436 pages, which is used as a text-book in various colleges and universities.

Q. What do you mean by the term "sewage". I wish you would state, Prof. Winslow, and also state what happens to it when it is discharged into bodies of water?

A. Sewage may, perhaps, best be defined as the liquid waste of human life. It includes, primarily, the water supply after it has been used for cleaning and cooking, etc. The feces, urine, and other excreta of human beings, the washings of the streets, the wastes from factories, slaughter houses, creameries, breweries, and other industrial establishments. After all, however, it is mostly water, at least 999 parts out of a thousand. Fresh sewage looks very much like the dirty water in a wash bowl, being somewhat milky in appearance and not particularly offensive either to sight and smell except for the solid particles of feces which float in it.

On the average, American sewage will contain perhaps 800 parts of solid matter in a million parts of water. Of these 800 parts about 300 consist of mineral matter in solution, including substances like common salt. This portion of the sewage has little practical significance. About 100 parts consist of mineral matter in suspension, largely sand and gravel from street washings, and sometimes this amount may be very much larger. It deposits and helps to form sludge banks and to clog and interfere with sewage purification devices. The other 400 parts of solid matter are organic in nature and it is these which furnish the serious problems of sewage purification. About 240 parts are in solution and 160 are in suspension as floating matter.

Besides the matter which is in gross suspension and that which is in the state of true solution, there is a certain portion which may amount to one-quarter of the total organic matter present which is in what is commonly known as the state of colloidal suspension. In other words, it is too finely divided to settle out and yet is not
2430 in a true state of solution and produces the impression of turbidity in the sewage. This material offers a particularly difficult problem in the purification and disposal by dilution.

The principal constituent of sewage which makes its disposal difficult is, of course, the organic matter in solution and suspension. The organic molecule is an enormous unstable mass of some thousands of atoms which constantly tends to break down into simpler elements. Under certain circumstances this breakdown is accompanied by the foul odors of putrefaction and decay. The object of sewage disposal is to secure the decomposition of this organic molecule along inoffensive lines. Whether the decomposition shall be objectionable or not depends entirely on the supply of oxygen.

When a small amount of sewage is discharged into a large volume of water its elements are soon oxidized by the action of bacteria present in the water and it is ultimately converted almost entirely into harmless mineral substances, without the production of any offensive odors whatsoever. If, on the other hand, the oxygen supply is insufficient the decomposition follows an entirely different course. Instead of oxidation, the organic molecule undergoes putrefaction, a partial breakdown into substances which themselves are unstable and which yield foul and offensive odors, such as are characteristic of an uncared-for garbage pile or privy vault. There is a critical point in stream pollution beyond which conditions entirely change. So long as there is an excess of oxygen, or, in technical terms, as long as aerobic conditions are maintained, everything goes well. The organic matter is oxydized into completely stable forms without offence and the process can go on for an indefinite period with eminently satisfactory results. Just so soon, however, as the oxygen falls below a certain point, conditions are totally changed, becoming anærobic instead of ærobic. Instead of a purifying stream we have a foul cess-pool or septic tank and conditions become progressively worse the longer they continue. The results to be expected from the discharge of sewage into water depend then entirely
2431 upon the relative amounts of sewage and oxygen-containing water into which it is discharged. In a given stream or harbor it may be perfectly successful for a long period of years, and when the critical point is passed conditions may rapidly become intolerable.

It must be remembered, of course, that the problem is in large degree a local one. Sewage is never completely mixed with a whole volume of harbor water or with the entire flow of a river. A harbor which is in general large enough to absorb all the sewage discharged into it may show very grave nuisances at particular points near the sewer outlets. This danger is accentuated by the fact that a considerable portion of the sewage solids settles to the bottom and another considerable portion floats upon the surface. The floating portions are unsightly and offensive, even when the main body of water below is not excessively polluted, and in the same way the solids which settle out on the bottom may form foul aggregates of decomposing sludge at local points.

Q. Have you made a study of the present condition of New York Harbor in regard to sewage pollution?

A. I have been familiar with the harbor for many years and have had ample opportunity to observe its condition from the decks of large and small boats at various times. On October 4, 1910, I made a trip through the East and Harlem Rivers in company with Dr. G. A. Soper of the Metropolitan Sewerage Commission and made a somewhat careful examination of the principal sewage outfalls. I am familiar with most of the published reports dealing with conditions in the harbor, including those of the New York Bay Pollution Commission and the two Metropolitan Sewerage Commissions, and the report made by Col. Black and Prof. Phelps, and I have studied the exhibits in this case.

Q. How do you find the present condition of New York Harbor as to sewage pollution, based on your own knowledge of the harbor and on the bacteriological and chemical data that you have examined in relation thereto?

Mr. Riker: The question is objected to on the ground that it is a hypothetical question in effect, and the matters which are
2432 intended for the consideration of this witness are not stated in the question so that counsel or the court can determine whether or not they are actual matters of fact proved in the cause.

The Commissioner: Note the objection of counsel for defendants.

A. The main channels of the Hudson and East Rivers are polluted to the extreme limit of their safe purifying capacity, while many of the bays and local areas near the docks have already passed beyond this limit.

The amount of sewage discharged into the harbor is very large. With a population of six million persons for the Metropolitan District in 1910, and assuming a sewage flow of 150 gallons per capita, which is an exceedingly conservative assumption, the harbor waters receive some 900 million gallons of sewage per day. This would make a river 18 feet deep and 100 feet wide and 13 miles long, and the solid matter daily discharged into the harbor amount to nearly 1,500 tons. All this polluting material is not discharged into a stream but into a land-locked harbor with a tide which carries it back and forth in the vicinity of the city sometimes for periods of days, with a comparatively small admixture of clean land water from above and clean sea-water from below.

The bacterial tables in this case show that the average number of bacteria in the main channels of the Upper Bay is over 12,000 per c. c. compared with 4,900 at The Narrows, and 1,600 in the Lower Bay. These are from the tables of averages for the year 1909. Many parts of the harbor show counts varying between 10,000 and 100,000 bacteria per c. c., and the numbers rise to over 1,000,000 per c. c. at points of special pollution. These figures in my judgment indicate considerable general pollution and very great local pollution. The most significant results of the studies which have been made are those in regard to dissolved oxygen. The 1911 tables of oxygen averages indicate that the waters of the Upper Bay near Robbins
Reef contain about three-quarters of the oxygen necessary for
2433 saturation. This is a reasonably safe margin and indicates good conditions at that point. On the other hand, analyses at the mouths of the East River and the Hudson show only about 55 per cent. of the oxygen saturation. This indicates in my judgment that these waters are on the danger line and cannot suffer any important increase in pollution, either direct or indirect, without danger of grave nuisance.

Conditions offensive to the eye are very general in the upper harbor. Near sewer outlets one notices a brown or gray turbidity and an oily sleek, with obvious masses of fecal matter. This condition forces itself upon the attention, but away from the sewer outlets and in the main channels of the upper East and Hudson Rivers, anyone

who looks carefully at the surface of the water will be disgusted by the sight of floating feces.

Q. What future conditions do you anticipate if New York Harbor continues to be used for the disposal of the sewage of the Metropolitan District as at present?

Mr. Riker: The question is objected to on the ground that it is not relevant to this issue. That the subject of this inquiry is the proposed discharge of the Passaic Valley Sewer.

The Commissioner: Note the objection of counsel for defendants.

Q. Proceed.

A. By 1940, it is reasonable to assume according to data which have been put in evidence in this case, that the population of the Metropolitan District will have doubled and will be approximately 12,000,000. If we assume that 80 per cent of this population is connected with the sewerage system, that will give a contributing population of 9,600,000. 150 gallons per capita per day would be a very conservative estimate for the amount of sewage to be discharged. In some studies made by Prof. Phelps and myself it appeared that in Boston the per capita flow was nearly 250 gallons. 150 gallons per capita with a population of 9,600,000 gives a sewage discharge of approximately 96,000,000 cubic feet in a period of twelve
2434 hours. The water available for dilution amounts, according to the estimates placed in evidence in this case to about 2,210,000,000 cubic feet of tide water and 1,180,000,000 cubic feet of land water for the same period of 12 hours. This gives a ratio of one part of sewage in 35 parts of water, against a ratio of about 1 in 80 at the present time. This is a condition which will certainly prevent the proper digestion of the sewage by the harbor. A great deal of experience which has been accumulated in Massachusetts and elsewhere makes it clear that 1 part in 50 is about as much as river and harbor waters can assimilate without anaerobic conditions and offensive putrefaction.

Unless radical means are taken to protect the harbor waters, they will, long before 1940, be converted at many points into foul and noisome open sewers.

It must be remembered, too, that even the conditions which exist at present will probably not be tolerated in 1940. There is a continual and progressive rise in sanitary standards which is likely to go on with accelerated rapidity. Our forefathers threw their slops out of the window or discharged them by pipes directly into the street but today we demand that our public thoroughfares and parks on land should be kept scrupulously clean. The harbor is the greatest public thoroughfare and park of New York City, its greatest pleasure ground and one of its greatest commercial assets. It is almost as undesirable that boats traversing it should plow their way through fields of putrefying sewage as it would be to have the wheels of our carriages and automobiles pass through pools of sewage on the land.

Q. Can you state, Prof. Winslow, what the effects of excessive sewage pollution on tidal and other waters are?

A. I can. Aside from the question of New York Harbor I have made somewhat extensive studies of the effects of sewage disposal in the harbors of Boston, Lynn, and New Bedford, Massachusetts, in the Chicago Drainage Canal and its branches, and in various Massachusetts streams. While connected with the Mass-
2435 chusetts State Board of Health I had excellent chance to become familiar with the results of sewage discharge in such streams as the Neponset, the Nashua, the Ten Mile and the Charles, which received more than one part of sewage in 20, and are heavily polluted; and also in such streams as the Merrimac, the Connecticut, Qualsoag, the Westfield, the Ware, the Millers River, which receive less than 1 part of sewage in 50, and where the pollution is local rather than general.

Q. Have you made studies of the composition of sewage in relation to population in various European and American communities?

A. I have. It was necessary to go into this subject in some detail in connection with the work of the Sanitary Research Laboratory and Sewage Experiment Station in Boston and in the preparation of a text-book on Sewage Disposal written by the late Prof. L. F. Kinnicutt, Mr. R. W. Pratt and myself.

Q. Assuming a population of 734,000 connected with the Passaic Valley Sewer in 1910, and a population of 1,649,000 connected in 1940, what would be the probable amounts of the various constituents passing through the main sewer?

A. For such a community as that in question I think a safe per capita estimate of the principal constituents would be as follows: Total suspended solids, 90 grams per capita per day; organic suspended solids, 60 grams per capita per day; nitrogen as free ammonia 10 grams per capita per day; organic nitrogen, 5 grams per capita per day. These estimates are, I think, exceedingly conservative. They are larger than the amounts recorded for some small cities and very much smaller than the amounts recorded for certain large cities. As a general thing, the per capita amount of various sewage constituents increases rapidly with the size of the community, as indicated by the table below, which is prepared from the data collected by Prof. Kinnicutt, Mr. Pratt and myself for our book. This table shows a marked increase in all the various constituents with an increase in the size of the community. The excess in the larger cities is due in part to the fact that where there are large areas of paved streets and courts almost all the rain water finds
2436 its way into the sewers, carrying its burden of horse droppings and waste materials of various kinds, while in more rural districts a good deal of the surface wash never gets into the sewers at all. Another and more important reason probably lies in the fact that the city has so large a temporary population during the daytime. The population contributing sewage during the day in the lower part of Manhattan Island is obviously enormously in excess of the census population, and the same thing is true to a less extent with all urban communities. I have here a table showing the per capita amounts of various constituents in sewage for cities of different sizes. Shall I read that?

Cross-examination by Mr. Riker:

Q. What are these figures based on in this table Professor?
A. These figures are based on larger tables of the actual analysis for a considerable number of cities.
Q. Made by whom?
A. Made in the various cities. Collected first, the large tables were prepared in this book by Mr. Pratt, to which I have referred, by Mr. Pratt and Prof. Kinnicutt, and myself. The original data were obtained from the city reports. This small table is prepared from the large tables.
Q. And the averaging of the tables that you referred to, that you secured?
A. These are not averages; they give the extreme values. In each case the extreme range is given the smallest value and the largest value for the group of cities.
Q. They give then the lowest of a group of cities, and the highest, is that it?
A. Yes.
Q. Then how did you group these cities?
A. According to their size.
Q. By any recognized standard of grouping?
A. These cities fell inevitably into two classes. That is, the rural communities, which have populations of, I suppose, a few thousand, and the larger cities in the United States, including Boston and Columbus, Providence, cities of that type, the intermediate class, or cities like Brockton and Gardner, Massachusetts.

2437

Q. Well, who determined these classifications?
A. I did.
Q. It is not recognized by anyone else, is it?
A. The populations of the cities are given in the tables.
Q. You think that, taking these things, that everyone would agree as to what were rural communities, with your classification?
A. I think in the case of the cities included here they would.
Q. You think that a rural community is so well defined that there would be no doubt as to whether or not your classification was a proper one?
A. I think it would be clear in the case of those particular places.
Q. I am asking about these particular places. You think the classification of rural communities is so well established and recognized that the ones you have included in that classification would be so included generally, do you?
A. I think so.
Q. And is that true of your classification of small cities?
A. I think so.
Q. Well, what is a small city?
A. I should rather give you the actual sizes of those cities if I may do so.
Q. You are giving a classification, and I would like to have you

indicate in that classification what is a small city, under your own classification?

A. I should like to answer that by giving the actual populations included in that.

Q. I do not care for that. Is there a recognized, in general scientific use in any way, a classification of small cities, and what are its limits?

A. I should call a small city one between 3,000 and 50,000 population.

Q. Well, does this classification of yours mean anything more than that you have selected certain cities and given the limits in those cities that you have selected, and that you have designated as small cities?

A. No, nothing more.

Q. That is all it means?

A. Yes.

2438 Q. And the data upon which you have based this table, so far as the per capita amount of various constituents in sewage is concerned, is nothing that is within your knowledge, except in a few of these cases?

A. Only in the case of Boston.

Mr. Riker: The table is objected to on the ground that it is not based upon any proven fact in this case and is immaterial and irrelevant and hearsay.

The Commissioner: Note the objection of counsel for defendants.

Direct examination by Mr. O'Sullivan (resumed):

Q. Proceed, Professor, state the contents of that table.

A. The table is as follows:

Per Capita Amounts of Various Constituents in Sewage for Cities of Different Sizes.

(Chemical Data in Grams.)

	Rural communities, Mass.	Small cities, Mass.	Large cities, U. S.	European cities.
Volume Gallons	25-94	25-110	85-280	25-6
Nitrogen as Free Ammonia	3.5-5.7	4.2-10.8	5.0-12.9	3.9-5.8
Nitrogen as Albuminoid Ammonia	.6-.9	1.2-2.1	2.8-2.9	1.4-2.8
Suspended Solids	14-32	42-70	96-152	65-178

In view of these facts the estimates which I have just given for the Passaic Valley Sewerage District are seen to be conservative. Transformed into the actual amount of matter carried through the Passaic Valley with main sewer, may be indicated in tabular form as follows:

2439 *Tons of Solid Matter and Nitrogen to be Carried Daily by the Passaic Valley Sewer.*

	Total suspended solids.	Organic solids.	Nitrogen. As free ammonia.	Nitrogen. As organic nitrogen.
1910	65	43	7	4
1940	146	97	16	8

Population 1910..... 734,000
" 1940..... 1,649,000

Q. In what condition would you expect to find the sewage at the outfall of the main sewer of the Passaic Valley Sewerage System in regard to its tendency to absorb oxygen from our harbor waters?

A. In considering the probable result of any system of sewage disposal, two things are of great practical importance, the composition of the sewage, that is the amount of organic material and solid matter it contains, and the condition of the sewage, that is the state of decomposition that the organic matter has reached. Fresh sewage as it is found in the upper part of a sewerage system is a comparatively inoffensive grayish liquid which usually contains an excess of free oxygen and also oxygen in the form of nitrites and nitrates. If such sewage can be purified or diluted at once there need be no evolution of offensive odors. As the sewage flows along through the sewer, however, the oxygen present is quickly used up, anaerobic conditions set in and the sewage becomes stale and later may be distinctly septic. This means that the putrefactive breakdown of the organic matter has begun. The sewage turns black and foul odors are evolved. I gather from data in evidence in this case that much of the
2440 sewage by the time it reaches the outfall works of the Passaic Valley system will be over twelve hours old; it will be, therefore, highly septic and offensive in nature, and in the condition to absorb most rapidly the oxygen in the harbor.

Mr. Riker: I shall move to strike out the testimony in regard to this witness's conclusions as to the condition of the sewage when discharged, as not being based upon any evidence that appears in this case that will be before the witness's mind at the time of giving this testimony. His evidence, if it is expert evidence, should be based upon hypothetical question stating the facts.

The Commissioner: Note the motion of counsel for defendants.

Q. Assuming the sewage from the proposed Passaic Valley Sewer to have passed, first through coarse screens, then through a grit chamber or basins, taking out the heavy matter as far as possible, then through self-cleaning, mechanical screens, having clear openings of four-tenths inch, then through sedimentation basins providing a detention period of not less than one hour and a half, with a mean lineal velocity of not over five-tenths inch per second, what would you expect to be the effect of such works upon such sewage as you have described?

A. The condition of the sewage to which I have just referred is one factor of prime importance which must be considered in estimating the efficiency of the purification works proposed. The length of the trunk sewer makes it certain that the sewage will be stale or septic when it reaches the works, and still more so when it is discharged at Robbins Reef; that the fecal solids will be largely disintegrated so as to pass through screens; and that the liquid will tend to be laden with finely comminuted matter and with a maximum of impurity in solution. These facts seriously limit the effectiveness of screens and sedimentation basins.

Coarse screens with openings of four-tenths of an inch will only remove coarser particles, sticks, rags, orange peel, etc., and will produce little effect on the stability of the effluent. As an outside estimate such screens could not take out more than 5 per cent. of the
2441 suspended solids in the sewage. The sedimentation basins with a detention period of one and a half hours and a mean lineal velocity of half an inch per second would in all probability remove not over 30 per cent. of the suspended matter in the sewage and 15 per cent. of the organic matter. In actual practice the improvement would often be considerably less than this, particularly in the summer when decomposition has proceeded farthest, and when the organic matter will be most thoroughly broken up.

Under the most favorable possible conditions, the projected screens and sedimentation basins can only be expected to remove the larger floating particles to diminish the sludge deposited in the harbor by about one-third, and to diminish the putrescible organic matter in the sewage by about one-sixth. Furthermore, this one-sixth will include the most stable portion of the organic matter, while all the most putrescible portions will be discharged in solution and fine suspension.

Q. Now, Prof. Winslow, assuming that the Passaic Valley sewage, so treated, is discharged into New York Bay at a point near Robbins Reef through a series of outlets 40 feet below mean low tide level, the outlets being 150 in number and distributed over an area of three and a half acres, what will happen to said sewage after its discharge?

A. The exact results to be anticipated from such a disposal plant are decidedly problematical. So far as I am aware there is no precedent for the discharge of so large a volume of sewage under such conditions, and it must be considered in the nature of an experiment. Judging from the results which have followed the discharge of sewage under somewhat comparable conditions, as in Boston Harbor, I am inclined to think that the sewage will rise rather rapidly to the surface and form a more or less continuous lake or pool over the disposal area. The sewage is very much lighter than salt water on account of its low salinity, its temperature and its fatty constituents. As a rule, sewage discharged under water rises very much as smoke does in the air as it issues from the chimney. The pool of
2442 sewage on the surface will remain concentrated at that point under conditions of slack tide and quiet atmosphere, or may

be driven by wind and currents to considerable distances just as a column of smoke is driven out through the air on a windy day.

Q. What probably would be the effect of such sewage discharge in the immediate vicinity of the outlet?

A. It would be very difficult to say, but the results would probably vary widely according to varying conditions. With a strong tide and a strong wind in Winter the sewage discharged might be hardly noticeable. On the other hand at slack tide *in* a warm muggy day, there would probably be created a considerable local nuisance, offensive to sight and smell.

The maximum flow as estimated by the Passaic Valley Sewerage Commission for 1940 is 357,000,000 gallons per day or 1,320 acre feet per 24 hours, or 55 acre feet per hour. This means that the whole dispersal area of three and a half acres will receive during an hour a solid mass of sewage which evenly distributed over the area would have a depth of 16 feet.

The data in evidence in this case indicate that for as long a period as 2 hours the tidal flow over the disposal area may be not over four-tenths of a foot per second. The sewage carried northward at the end of the flood will be carried back again over the disposal area at the beginning of the ebb, mixing with the new sewage being discharged at that time.

The digestion of sewage is always much more difficult in salt water than in fresh, as was made clear in the studies carried out in connection with the Charles River basin. This is partly because of the smaller proportions of oxygen which salt water holds as compared with fresh water, partly to the presence of sulphates which are easily reduced with the formation of effensive odors of hydrogen sulphide, and partly to other factors now not clearly understood.

One point in particular which should be taken into account is the presence of the wastes from industrial establishments. The
2443 1908 report of the Passaic Valley Sewerage Commission estimated the industrial wastes at 62,000,000 gallons per day. At Paterson is a large woolen mill, said to be the largest in the world, and wool waste is particularly hard to dispose of. I have had the chance to observe its effects in the Merrimac River and also the interference which it causes with the operation of the disposal works at Clinton, Mass. The wool scouring liquor will undoubtedly contribute materially to offensive and unsightly conditions around the outfall.

In view of all these facts I am inclined to think that at times of slack water the sewage from the Passaic Valley Sewer will often be visible at or near the disposal area as a turbid lake of dark and more or less septic sewage, in sharp contrast to the clearer waters of the harbor. Fine particles of suspended matter will at such times be distinctly visible. When sewage comes into contact with salt water there is a precipitation of fine colloidal matter which greatly adds to the visible pollution and grease balls of various sizes are likely to form as the grease is coagulated by the cooler waters of the harbor. Industrial wastes may at times produce still more marked discoloration.

Under certain conditions these offensive appearances will be reenforced by odors of putrefaction from the highly septic sewage discharged under unfavorable atmospheric conditions, such as humidity and slight wind movement, especially at times of slack water, foul and objectionable odors will, in my opinion, be detected in the vicinity of the disposal area and possibly for some distance from it.

Q. What probable effects would you expect from the discharge of such sewage affecting the more remote portions of the harbor?

A. The effect of the Passaic Valley sewage upon the more remote portions of the harbor would be a two-fold one, direct and indirect.

The direct effect of the sewage would, of course, be limited to the transfer by currents of unpurified sewage to other regions. Floating fields of sewage often retain their identity while carried by currents for considerable distances in the absence of strong wind ac-
2444 tion. The float experiments carried out by the Metropolitan Sewerage Commission are highly significant as to what may be expected. For example, from Complainants' Exhibit No. 58 it appears that Float No. 28 was, on September 16, 1908, carried on half a tide for a distance of five and 27/100 miles into the Kill van Kull. From Complainants' Exhibit No. 65 it appears that Float No. 35, on September 29, was carried on the flood 2 and 78/100 miles over to the Long Island shore, and then on the ebb to 2 and 68/100 miles southward along the shore. From Complainants' Exhibit No. 64 it appears that Float No. 34 on September 28 was carried by the flood tide up to a point near the New Jersey shore opposite 60th Street in Manhattan, a distance of 9 and 14/100 miles. From Complainants' Exhibit No. 66 it appears that Float No. 37, on October 1, 1908, was carried by the flood tide up to the Battery and then along close to the Manhattan shore of the Hudson River as far as West 11th Street, a distance of 6 and 87/100 miles. All these floats were started near the proposed disposal area, and fields of sewage will follow the same courses, given the proper conditions of tide and wind.

A second direct effect of the Passaic Valley sewage upon the more remote regions of the harbor will be due to the deposition of suspended organic matter. It has been noted that the sedimentation tanks proposed will not remove more than one-third of the total suspended solids. Considerable amounts of the remaining suspended matter including the most putrescible and offensive portion, will be discharged into the harbor and will settle out as soon as it is carried by currents to points where the velocity is less than five-tenths inch per second. Such deposits may cause a local nuisance through the formation of putrescible accumulations of organic sludge.

The disease bacteria discharged from the Passaic Vallew sewer will persist for a time in the harbor and some of them will be carried to considerable distances, so as to increase the danger which now threatens those who bathe in the harbor or eat shell-fish taken from it. The upper harbor is at present so much polluted from
2445 other sources as to be unsafe for such uses even now. The shores of Staten Island and Long Island on the Lower Bay beyond the Narrows are still however in reasonably good condition and the discharge of a large volume of sewage at Robbins Reef will

constitute a possible menace to the bathing beaches on Staten Island and Coney Island, and to the shell-fish beds on the southeast shore of Staten Island.

These are the principal direct effects from the Passaic Valley sewage on other regions of the harbor. It will also exert an indirect effect on all parts of the harbor by the consumption of dissolved oxygen from the incoming tidal waters. It has been made clear by recent studies that the reabsorption of oxygen from the surface of a body of water is comparatively slow unless heavy winds are blowing, and compared with the pollution which enters New York Harbor this factor is almost negligible. The oxygen which makes possible the assimilation of sewage in the Upper Bay is mainly that which enters through the Narrows and at Throggs Neck and from the Hudson River above, the principal fraction of the total amount being that which enters through the Narrows. The Passaic Valley Sewer outlet is situated just at the strategic point where it will tend to cut off the supply of oxygen which naurally enters through the Narrows and makes possible the maintenance of bearable conditions in the lower reaches of the East River and the Hudson. Even now, with 75 per cent. of the oxygen necessary for saturation present in the waters of the Upper Bay, the percentage of saturation in the East River and the Hudson falls to 55 per cent. If the main source of purifying oxygen for the whole harbor is diminished by the discharge of sewage into the main channel of the Upper Bay, the amount available for the waters adjacent to Manhattan will be correspondingly diminished; certain regions will become polluted beyond the critical point, and grave nuisances may follow even at remote points as the indirect result of the Passaic Valley sewage discharge.

Q. What will be the general effect of the discharge from the Passaic Valley Sewer on public health and welfare?

2446 Mr. Riker: The question is objected to on the ground that it does not appear in the evidence what the discharge from the Passaic Valley Sewer is to be, and that therefore this witness cannot testify as to the effects of something that is not yet determined in the evidence.

The Commissioner: Note the objection of counsel for defendants.

Q. Proceed.

A. The discharge of several million galons of sewage at Robbin's Reef will undoubtedly tend to produce an injurious effect upon the health of the community using the harbor, although such an effect will probably be a slight one. It will show itself in the greater pollution of bathing beaches and shell-fish beds, and will be most important in the regions of the outer bay which are now in reasonably good condition. There will be also a possibility of an effect upon the health of persons using vessels in the vicinity of the outlet; harbor waters are of course used on vessels for washing the decks and for other purposes, and when the water is polluted or infected there is danger of disease.

The most important effect will be the damage to the harbor as

a public highway and a public pleasure ground. The discharge at one point of this large volume of putrescible sewage will tend to injure the harbor for all purposes of human use by making it unsightly and malodorous, and by creating local nuisances both at the point of discharge and elsewhere.

Q. Have you had submitted to you the exhibits in this case numbering from 1 to 126?

A. I have.

Q. Have you read the hypothetical question put to Mr. Eddy?

A. I have.

Q. Now, taking all these facts and circumstances of record in this case, and the facts observed by you into your full consideration, what in your opinion will be the results of the contemplated discharge from the Passaic Valley Trunk Sewer outlet into New York Harbor in the vicinity of Robbins Reef, on the harbor
2447 waters and tidal waters of New York Harbor under present existing conditions and under prospective conditions on or about the year 1940, and during the intervening period between 1912 and the year 1940?

Mr. Riker: The question is objected to on the ground that it is not in proper form as a hypothetical question, and that it does not state so that the court and counsel may determine the facts upon which it is based, the matters that are supposed to be evidential and upon which the witness is asked to testify. It is further objected to on the ground that it does not appear that this witness has any knowledge of what the contemplated discharge of the Passaic Valley Sewer is, it appearing by his testimony thus far giving that, as a matter of fact, he does not know what the contemplated discharge is.

The Commissioner: Note the objection of counsel for the defendants.

A. If the present condition in the harbor were assumed to be maintained in 1940 with the exception of the fact that the Passaic Valley Sewer were in operation, discharging the sewage from a population of 1,649,000, the following results would in my judgment follow from that discharge: There would frequently be noted in the neighborhood of the outfall color, turbidity and oily sleek forming a lake or pool of sewage which would be unsightly and offensive to the eye, and odors of putrefaction would frequently be noticeable in the neighborhood. At times this sewage might be carried by the tide for considerable distances and produce local nuisances elsewhere. It would add to the danger which now threatens those who bathe in the harbor or use shell-fish from it; it would put a severe strain upon the digestive capacity of th harbor, and by lowering the available amount of dissolved oxygen coming in at the Narrows would probably produce serious putrefactive conditions in parts of the Hudson and East Rivers.

The discharge from the Passaic Valley Sewer in 1940 combined with the normal increase in pollution that may be expected
2448 before that time unless radical measures are taken to keep sewage out of the harbor, will, of course, produce much more serious conditions. In my opinion the conditions will become in-

tolerable in large portions of the harbor long before 1940, and some measure of sewage purification will be absolutely necessary.

The local nuisance at Robbins Reef will begin to manifest itself as soon as the sewer is put into operation. This and the more indirect effect upon the harbor waters will increase progressively with the increase in the amount of sewage discharge.

I am not concerned as an expert primarily with the effect of this Passaic Valley Sewer upon the city of New York. I am trying to consider the matter from a standpoint of all the communities concerned. The whole problem of what has been called the Metropolitan Sewerage District is one problem and should be met by a single comprehensive policy. New Jersey will in the end be injured quite as much as New York by any hasty and partial method of dealing with the matter and particularly by any plan which increases the present amount of putrescible sewage discharged into the harbor waters.

Mr. Riker: I desire to move to strike out the thought of this witness as being immaterial and irrelevant. The issue in this cause does not involve questions of policy of the state of New Jersey.

The Commissioner: Note the motion of counsel for defendants to strike out.

Q. Proceed.

A. In regard to the relative importance of this pollution in comparison with other pollution of New York Harbor, it should be noted that there are several respects in which this Passaic Valley Project presents peculiar difficulties. In the first place we shall have here a much larger concentration of sewage at a single point than exists in any of the main channels of the harbor. There are plenty of local nuisances near the docks, but so far as the principal channels are concerned the discharge from a large number of small sewer
2449 outlets secures pretty efficient dilution. Here, on the other hand, the sewage from 1,500,000 people will be discharged in 1940 practically at one point. In the second place, the Passaic Valley sewage, after its long journey through the trunk sewer, will be much more septic and decomposed, much more offensive and much more active in the removal of oxygen from the harbor water than the sewage now discharged from Manhattan and Brooklyn. Aside from the question of local nuisance, the crude method of disposal used in the Borough of Manhattan is excellently adapted to secure a fairly even dilution of fresh sewage with a large body of water, while the Passaic Valley sewage will be septic and will be concentrated in a large amount on a small area. Of course, the Passaic Valley Project is favored by the considerable volume of tidal flow at Robbins Reef. How far these favorable and unfavorable conditions will balance each other remains to be seen.

Q. Mr. Winslow, have you read the stipulation entered into between the United States Government and the State of New Jersey, which is in evidence in this case as Complainant's Exhibit No. 135?

—. I have.

Q. Do the terms of that stipulation modify or confirm you in the opinion you have just expressed?

A. When I first read the agreement between the United States Government and the State of New Jersey in regard to the Passaic Valley Sewer I was greatly impressed with it. On casual reading it seemed amply sufficient to protect the City of New York. On a more careful study of the document, however, I have come to a contrary opinion.

The agreement provides for certain specified works under Section 1 and for the attainment of certain specified conditions under Section 2. There arise therefore three distinct questions: First, are the stipulations as to results satisfactory; second, will the methods proposed attain the results promised; third, if not, are the stipulations as to reults of sufficient definiteness and are they of a nature to be readily determined and proven by observation or by other
2450 means available under the terms of the agreement, so that failure of the guaranteed works would be clear and the construction of "lawful additional works" imperative.

In the first place, as to the adequacy of the stipulations as to results, I am inclined to think that four of the guaranteed results would be satisfactory; while the other three would not. Stipulation 2 provides for the absence of deposits objectionable to the Secretary of War of the United States, in New York Bay coming from the Passaic Valley sewage. This obviously offers no guarantee against the formation of deposits objectionable to the city of New York but not to the Secretary of War of the United States. It is altogether possible that the United States Government might object only to deposits in important channels which would interfere with general navigation. The solids from the Passaic Valley sewer might conceivably be deposited in shallow waters so as to cause local nuisances or so as to interfere with the use of the harbor by small boats and interfere with oyster beds.

Stipulation 6 provides for the absence of injurious effect from said sewage discharge, upon the property of the United States situated in the Harbor of New York. This section is very broad and general but it clearly suggests the possibility of certain injurious effects upon property not covered by the other sections. If such a possibility exists in regard to the property of the United States it must also exist in greater measure in regard to the property of the State of New York and its citizens. In view of the numerous and varied property interests of the State of New York and its citizens, and the comparatively limited property interests of the United States, it seems altogether likely that the former might be injured while the latter were not.

Provision 7, which provides for, "The absence of reduction in the dissolved oxygen content of the waters of New York Bay, resulting from the discharge of Passaic Valley sewage, to such an extent
2451 as to interfere with major fish life," seems to me inadequate to protect the interests of the State of New York. It is possible that the Passaic Valley sewage might reduce the dissolved oxygen content of the harbor so as to interfere seriously with its general

digestive capacity and might thus tend to produce offensive conditions in other parts of the harbor without interfering with major fish life which is presumably confined to the main channels. Furthermore, there is no guaranty that minor fish life or shell-fish life would not be interfered with; and the limits set upon the stipulation might lead to the inference that such an effect may be anticipated.

The other four stipulations as to results, numbers 1, 3, 4 and 5, are satisfactory, but these results in my judgment will not be accomplished by the proposed works, and could not be accomplished by any works except at enormous expense. I have pointed out in my direct testimony that there will probably not be "absence in New York Bay of visible suspended particles coming from the Passaic Valley Sewer," that there will not be "absence in the New York Bay and its vicinity of odors due to the putrefaction of organic matters contained in the Passaic Valley sewage," that there will not be "a practical absence on the surface of New York Bay of any grease or color due to the discharge of the Passaic Valley sewage at the dispersion area or elsewhere." I do not believe it can be predicated that "no public or private nuisance will be created thereby."

In regard to the definiteness and enforceability of the stipulations as to results the specifications may be divided into two classes: The provisions that there will be absence in New York Bay of visible suspended particles coming from the Passaic Valley sewage; and that there will be practical absence on the surface of New York Bay of any grease or color due to the discharge of the Passaic Valley sewage, at the dispersion area or elsewhere, are in my judgment, and from the standpoint of the sanitary expert, clear and capable of reasonable enforcement. At times and under certain conditions of tide
2452 and wind, suspended particles, color and grease from the Passaic Valley sewage might be so quickly dispersed and mixed with similar materials from other sources that their origin could not be demonstrated. It seems to me certain however, that under conditions which will ordinarily be met with in the harbor these visible qualities, if present in any degree to which objection could be taken, would be so much more intense at the dispersal area and so sharply contrasted with the conditions of the surrounding waters which receive no such intensive pollution, that there would be no practical difficulty in identifying their source.

The remaining provisions appear to me in greater or less degree incapable of reasonable and certain enforcement. The provision No. 2 that there will be absence of deposits objectionable to the Secretary of War of the United States in New York Bay coming from the Passaic Valley sewage, and the provision No. 6, the absence of injurious effect from said sewage discharge, upon the property of the United States situated on the Harbor of New York, are, of course, unenforceable, so far as New York is concerned, on account of the fact that the United States authorities specifically under 2 and implicitly under 6 are made the sole judges of their fulfilment. Furthermore, both specifications appear to me intrinsically unenforceable. The deposition of solid matter from the Passaic Valley sewer would be a slow and progressive one except near the outfall and it

might take place in remote parts of the harbor. Under the circumstances it would be quite impossible to prove that the deposits came "from the Passaic Valley sewage." The same objection applies to the vague provision as to "injurious effects." Such an effect would be slow and gradual and perhaps blended with injurious effects from other quarters, so that the exact source of injury would not be conclusively traced to the Passaic Valley sewage discharge even though that were in part its main source.

Provision No. 3, that there will be absence in New York Bay and its vicinity of odors due to the putrefaction of organic matters
2453 contained in the sewage thus discharged, would be extremely difficult of enforcement. There might be times when the odor was so strong directly in the vicinity of the dispersion area as to preclude any probability if its emanating from some other source. There will undoubtedly be times, however, when the odors will be less definitely noticeable and it would then be more difficult to fasten the responsibility upon the Passaic Valley sewage. Furthermore, there might be times when the odor from the Passaic Valley sewage might be overshadowed by odors from other sources, such as industrial plants at Constable Hook, either from the plants themselves, or from the products discharged into the waters of the Kill van Kull. Under such conditions the Passaic Valley sewage might contribute materially to malodorous conditions in the harbor and yet it might be impossible to trace the trouble definitely to its source.

There is another ambiguity in this section due to the provision that the odors to be absent shall be only those due to "putrefaction of organic matters." There might be other odors than those due to putrefaction of organic matter, as for example those produced by certain industrial wastes, and until there is a more definite understanding and acceptance of the term "putrefaction" as applied to odors I am of the opinion that this section may prove unenforceable on this ground.

Provision No. 5, there will be no injury to the public health which will be occasioned by the discharge from said sewer into the Bay of New York in the manner proposed and no public or private nuisance will be created thereby, is practically unenforceable with respect to public health, since the danger is remote and the channel of infection difficult to trace and since its effect is tied up with the identity of the sewage "from said sewer." With respect to the public nuisance, it might be partially enforceable in so far as the conditions in the vicinity of the dispersion area produced a nuisance obviously definable by comparison with the waters at a distance from the dispersion field. If, however, the nuisance was not so clearly definable but still existed the action would be unen-
2454 forceable owing to the difficulty of excluding any other source than that of the Passaic Valley sewage.

Provision No. 7, calling for the absence of reduction in the dissolved oxygen content of the waters of New York Bay, resulting from the discharge of Passaic Valley Sewage, to such an extent as to interfere with major fish life, seems to me entirely unenforceable.

The term "major fish life" is an indefinite one. We know very little about the effect of different amounts of oxygen upon fish life of any kind, and it would be almost impossible to prove that any decrease of fish life which might occur was due to a reduction in dissolved oxygen content. Finally it would be very difficult to prove that a decrease in dissolved oxygen, unless strictly localized near the dispersal area was a result of the discharge of Passaic Valley sewage, even though such might be the case.

Q. Prof. Winslow, are there other available means for a proper disposal of the sewage of the Passaic Valley other than by its discharge through a trunk sewer outfall at Robbin's Reef?

Mr. Riker: The question is objected to on the ground that it involves a question of policy of the Supreme State of New Jersey, which is not involved in this issue and is immaterial and irrelevant.

The Commissioner: Note the objection of counsel for defendants.

A. There are no serious difficulties in the way of the proper disposal of the sewage from the Passaic Valley District by other methods than discharge at Robbin's Reef. It should be noted so far as the main harbor is concerned this sewage is now purified to a considerable extent merely by its storage in Newark Bay, which acts as a natural sedimentation basin. It appears from the analyses of the Metropolitan Sewerage Commission in evidence in this case that the water at the outlet of Newark Bay contains 64 per cent. of dissolved oxygen against 55 per cent. at the mouth of the East River, showing how considerable is the purification that goes on there. By the use of adequate sedimentation basins and trickling filters or other modern processes of sewage disposal there is no reason why the local nuisance in the Passaic River cannot be done away with at a reasonable cost without the discharge of partially sedi-
2455 mented sewage into the main channel of New York Harbor.

There is a marked and progressive tendency toward greater care in the protection of harbors and inland waters, as the effect of pollution becomes more and more serious year by year. At Boston it has already been found necessary to limit the area from which sewage can be discharged into the harbor to the towns in the immediate vicinity of its shores and towns a few miles inland are being compelled to install purification works of their own. In the plans proposed for the discharge of the sewage of Rochester into Lake Ontario it is planned to remove the fine organic matter by the use of screens with a mesh of .08 inch, five times as fine as those planned for the Passaic Valley system. The recent plans for sewage disposal at Milwaukee not only contemplate screening and sedimentation but include provisions for trickling filters and for a disinfection plant which it is felt may ultimately be necessary.

Mr. O'Sullivan: Your witness.

Cross-examination by Mr. Riker:

Q. Prof. Winslow, you do not agree with some other witnesses in this case that there is a limit of the reduction of dissolved oxygen in

the harbor waters that will be dangerous or destructive to major fish life?

A. I have no idea what that limit is.

Q. You would not place the limit of 70 per cent. as the limit?

A. I know of no data which would enable me to fix the limit based on the effect on major fish life.

Q. If any of the witnesses for the complainants testified that that was the limit, you do not agree with them?

A. I do not degree or disagree.

Q. You do not know?

A. I do not know.

Q. And you have no opinion about it?

A. No.

Q. So that you have no way of fixing what degree of exhaustion of oxygen due to the discharge from the Passaic Valley Sewer affects the major fish life in the harbor?

A. No.

2456 Q. You do not have any difficulty in your examination and consideration of this stipulation with the legal features of it?

A. That is not mine.

Q. I ask you whether you have or not, have you any?

A. I am not sure that I understand what you mean by difficulty.

Q. Do you have any difficulty in understanding whether the word "lawful" means legal or not, as used in the stipulation?

A. No, I have not considered that.

Q. You have not considered it as having any difficulty at all, in your mind, in considering the stipulation?

A. No. It has no effect upon my judgment on the effluent.

Q. And, are you assuming, in your testimony, that in case the specified purification means, as described in the stipulation, do not produce the effluent that others are to be added to them. Do you understand that, or don't you, under the agreement?

A. Provided it can be proved that the guaranteed results are not attained, yes.

Q. You understand there are other devices or methods of purification to be applied to the sewage in case the stipulated results are shown not to have been produced?

A. Yes.

Q. Now, I understand you to say that there were certain of these stipulated results, which, from a practical point of view, could be determined in the effluent to be discharged into the harbor waters?

A. Yes.

Q. Will you just state what those are?

A. I think the provision in regard to the absence of visible suspended particles, and the absence of grease and color will obviously fail to be met at times.

Q. Well, I know, but it can be determined whether or not it is being complied with in the effluent?

A. I think so in regard to those two stipulations.

Q. If those two stipulations are complied with will it not follow as a scientific certainty that the others will be complied with?

A. No. Those simply deal with visible surface conditions. There might or might not be exhaustion of the dissolved oxygen. There might or might not be danger to health, whether or
2457 not there was turbidity or color present. They are an entirely separate factor.

Q. You think also there may be deposits on the bottom of the harbor if there are no visible suspended particles on the surface?

A. It is possible. I do not think it is likely.

Q. Not likely, is it. It is probable that if those two stipulations are carried out that one at least will follow?

A. I think it is probable, yes.

Q. What about odors?

A. I do not think they would have any connection with the others.

Q. No connection between the odors and the visible suspended particles or grease and scum on the surface?

A. No, because odors are mainly due to the matters in solution. If, for example, matter was highly septic, it might have no suspended particles, but it would have the worst conditions in regard to odors.

Q. If it was highly septicized there would be no suspended particles you say?

A. There might be no suspended particles.

Q. And there might be no grease or scum on the surface of the water?

A. Conceivably, yes. Those might be taken out by works designed for that purpose, without affecting the putrescibility.

Q. You think, do you, that odors that might be the result, at the discharge point, from this sewer, might not be determinable as coming from the sewage?

A. Yes, at times it might not be possible to determine whether they came from there or not.

Q. Most of the times it would, would it not?

A. I should not say that. It is pretty hard to trace odors, because I know how difficult it is to trace the source of odors.

Q. Then that is a very fanciful kind of requirement, in your judgment, in the matter of odors?

A. No, that seems to me to be quite a vital one.

Q. If the odor is due to the presence of this sewage in the harbor, notwithstanding that it is a vital one, you think it would be
2458 difficult to trace it to its source?

A. Very difficult, yes, sir.

Q. Having a disposal area at a definite point, definitely located in the harbor, which is causing odors, you think it would be hard to trace them to that source?

A. I think so.

Q. You have testified to some other sources of odors that might possibly be confused with those from this particular source. What were they?

A. I think I mentioned no specific source.

Q. Did you not mention Hunter's Point?

A. At Constable Hook.

Q. Any difficulty about tracing those to their source?

A. I never tried, but I imagine there would be.

Q. You identified that, in your judgment, did you not?

A. Yes.

Q. As something that is recognized as odors that come from a distinct source?

A. I think, however, in fact, I am sure, that it would be pretty hard to legally establish the origin of those odors. I say that because I have spent nearly the whole of one summer with two assistants in trying to fix the responsibility for the odor nuisance at the New England Gas and Coke Works near Boston, and I obtained there a very clear idea of the difficulty of definitely proving that certain trouble came from a certain source.

Q. Now, if the odors, the anticipated odors, from this source cannot be traced by reason of this confusion due to other odors that are present, what is the damage in your judgment from the particular odors from this source?

A. I think every addition to a bad condition has its own definite weight aside from other conditions.

Q. And you think that such an addition as cannot be identified in any way or traced to its source is sufficient to consider in this connection?

A. I think a great many odors, which constitute a very serious nuisance, it is almost impossible to trace legally back to their source. You can see a cloud of smoke coming from a chimney, but we cannot use our nose in as precise a way as we do our eyes.

Q. You say that you cannot be sure of being able to de-
2459 termine whether there is injury to the public health from the discharge of this sewage into the bay?

A. Yes, I think it would be quite impossible to show that.

Q. It is quite impossible to determine any injury to the public health from the present discharge of the sewers of the city of New York, is it not?

A. I think so. In my judgment it is.

Q. You would not be sure that there were any diseases due to the discharge of the present sewage of the city of New York?

A. I am reasonably certain that some diseases might be caused by that condition, but I have no scientific evidence of it.

Q. You think that there will be difficulty in determining whether or not public or private nuisances will be created by the discharge?

A. I think so.

Q. Why?

A. That comes back partly to the question of odors, which, as I say, is one exceedingly hard to put in tangible form, and the question of what constitutes a nuisance in the way of unsightly substances in the harbor.

Q. A public or a private nuisance. Now, just what are those to be anticipated from this discharge?

A. Mainly, in my judgment, the presence of sewage matter,

turbidity, oily fecal matter visible in the water, and the presence of odor from that.

Q. Now, there being no difficulty in determining the visible suspended particles, you eliminate that?

A. I think it would be hard to establish whether they constituted a nuisance or not.

Q. If they were visible they would be in violation of that stipulation which you say is recognizable and enforceable?

A. Yes.

Q. So that, if those things, if the ones that you say are enforceable and can be identified are actually carried out you will not expect that class of nuisance?

A. No sir.

Q. What class of nuisance will you expect?

A. If there are no visible suspended particles, no color or grease, the only nuisance could be the odor.

2460 Q. The only nuisance that you think there is any danger of encountering under this stipulation, that could not be identified with this as the source of it, is the odor?

A. Yes.

Q. And that is substantially a repetition of your criticism of the third item of the stipulation with reference to odors?

Mr. O'Sullivan: I move to strike out this running comment of counsel, and the inferences which he draws. They are not proper questions.

The Commissioner: Note the objection of counsel for complainants. Note the motion to strike out.

Mr. Riker: The usual practice is to object to questions and not to move to strike them out.

Mr. O'Sullivan: I have not objected to the question. I have objected and moved to strike out the running comments which are entirely unsubstantiated by the testimony of the witness.

Mr. Riker: Counsel again suggests that the proper method of objecting to the form of the question is by objection and not by motion to strike out.

The Commissioner: Note the objection of counsel for complainants and motion of counsel for the complainants.

Q. So that these public or private nuisances created by the sewage as contemplated from the Passaic Valley Sewer which will not be identified, are the odors, is that it?

A. Yes.

Q. That is the only nuisance?

A. Assuming that there is no visible suspended matter or no oil or color, and assuming that there is no suspended matter below the surface, the only thing left is the odor.

Q. The seventh item with reference to the absence of reduction of dissolved oxygen in the waters of New York Bay resulting from the discharge of the Passaic Valley sewage, to such an extent as to interfere with major fish life. I think you have already said that you

could not say one way or the other with reference to that
2461 because you do not know what the limit of dissolved oxygen for the support of major fish life is?

A. Yes.

Q. Now, as to the sixth specification of the stipulation as to this effluent, the absence of injurious effects from said sewage discharged upon the property of the United States situated in the harbor of New York. If the items of the stipulation which you say can be determined as to whether or not they are being carried out, are carried out, have you any doubt that that one will also be complied with?

A. No, I think the main injurious effect to be looked for is the result of odor and the result of the action of polluted water on the paint of boats, on piers, on docks, and so on, and that would be due mainly to the matters in solution, which are not covered by the part of the stipulation to which you referred. Of course, this question of odors, I do not intend to limit the region around the dispersion area, because, if that sewage is discharged low in oxygen, so as to reduce—that is, so as to render the waters of the Upper Bay low in oxygen, that may, as I have tried to indicate, produce nuisances in remote portions of the harbor; produce odors up in the East River and the Hudson River, and in the slips at many points.

Q. You are familiar with the Hudson River and the slips that you have been speaking of?

A. Yes.

Q. And you are aware of the conditions in them with reference to the sewage of the city of New York?

A. I am.

Q. Do you mean to say that there will be any odor produced if this stipulation is lived up to in the respects in which you say it can be determined whether or not it is lived up to or not. Do you say that there will be any perceptible odor?

A. Yes, there certainly will. You can divide the waters of New York Harbor into two classes. Waters that are at present offensive, like the slips where the sewers discharge. There are certain waters which probably would not be offensive even after the Passaic Valley Sewer were in operation. Then, there is a middle class of waters
which are just on the safe side of the line now. They would
2462 be pushed over the line and made putrescible by the addition of this extra load. The average analysis at the mouths of the Hudson and East River, showing about 55 per cent. of dissolved oxygen, indicate to my mind on the whole that the East Hudson River main channels are about on the danger line. That is why any extra burden seems to me to be so serious now.

Q. Now, Prof. Winslow, assuming that the city of New York adopts purification methods equal to those contained in this stipulation for the Passaic Valley sewage, in your judgment will there be any perceptible reduction in the oxygen content of the harbor of New York?

A. Well, you mean balancing the present New York conditions, without the Passaic, against improved New York conditions, plus the Passaic?

Q. The Passaic Sewer?

A. Well, I cannot tell.

Q. Would you say that a very marked improvement in all the waters of the harbor would be produced by the adoption of the specific requirements of this stipulation by the city of New York?

A. Certainly the stipulation as to the sedimentation basins and screens would produce a very marked improvement. Of course, when you consider the relative merits of isolated disposal points in detail, that is another question.

Q. You can take the question either by a central plant or by separate disposal plants?

A. As I have indicated, I think this plant will take out one-third of the total solids and one-sixth of the organic matter.

Q. And that applied to the present discharge of the city of New York would help very materially the present conditions of the water in New York Harbor?

A. It would help the general putrescibility about one-sixth and the other about one-third.

Q. Suppose that the effluent would be of a character so as to produce in the waters of the harbor from the sewage of New York City the results set forth in this stipulation as to the effluent from the Passaic Valley Sewer. Would or would not that cause a very marked improvement in the waters of New York Harbor?

A. It would, a very marked improvement.

2463 Q. Would, in your opinion, there be likely to be any real objection to the conditions of the waters of the Harbor of New York under those conditions?

A. That is provided the stipulations as to results—yes, sir.

Q. Yes, sir.

A. Were transferred over to the——

Q. Transferred over to the discharge from New York?

A. If the stipulations in regard to the absence of visible suspended particles and the absence of odors due to putrescibility, and the absence of grease or color, absence of any damage to health, or the creation of any public or private nuisance, if they were fulfilled in regard to the sewage of New York there could, obviously, be no objection to that discharge, except in regard to the possibility of sludge deposits and injury to fish life. Those are the other two points that do not seem so clear.

Q. Now, Professor, if from an effluent there is removed the light matter which is likely to remain in suspension, will there, in your judgment be any sludge produced from that effluent?

A. Well, of course, that depends on the method. You can scrape off the scum and the floating matter from sewage.

Q. Is the sludge and floating matter, in your judgment, synonomous with suspended matter?

A. Pardon me, I was thinking of the grease. Of course, if you remove all suspended matter, you would have no sludge. Of course, this statement is "visible suspended matter." Very fine particles that would not ordinarily be visible would form a certain amount of

sludge. If sewage is purified, so as to be pure to the eye, it would not form any sludge.

Q. And would or would it not be negligible as compared with the deposits from the natural flow of a river like the Hudson River?

A. If there were literally no suspend particles it would, of course, yes.

Q. If an expert produced by the complainants testified that if these particular stipulations, which you have been dealing with, the ones that might be enforceable, practically, if they were lived up to there would be no substantial reduction in the dissolved oxygen, do
2464 you or do you not agree with that?

A. I do not think there is necessarily any relation between suspended matter and grease and color and dissolved oxygen.

Q. No necessary connection between the power of the sewage to consume dissolved oxygen and the suspended matter and grease and sludge?

A. No. Rather the reverse, because the common processes used to take out suspended matter increase the putrescibility of the liquid.

Q. And if, in the taking out of the suspended matter the organic matter is taken out, does or does not that effect the oxygen assimilating powers of the sludge?

A. In many processes that organic matter is taken out by putting it into solution, by breaking it up and putting it into solution in most unstable form. In other processes that is removed without any such putrefaction.

Q. Have you not calculated on the removal of a certain percentage of the organic matter by the processes described specifically?

A. Yes, I believe that would take out about one-sixth.

Q. To that extent they would reduce the power of the sewage to diminish the oxygen or take up the oxygen of the water?

A. Yes, I think so.

Q. Now, under objection, you testified to the possibility of establishing other means of disposing of the sewage of the Passaic Valley?

A. Yes.

Q. What were those means that you had in mind when you said that?

A. I had not in mind any specific methods for that problem, because I could not suggest specific means without a study of the local situation. I had in mind simply the fact that reasonably effective and economical methods to dispose of the sewage of large cities are now available.

Q. Those methods that you now speak of, do they produce an effluent which, in your opinion, is less injurious than that stipulated for in this stipulation between the United States and the State of New Jersey?

A. The stipulation as to the results?

Q. Yes.

A. No. I do not think there is any method that can produce those stipulated results, except at enormous expense.

Q. And the ones that you had in mind as feasible and suit-
2465 able to be adopted in the Passaic Valley are ones that do not produce results that are to be compared with those stipulated for in this agreement?

A. Not in respect to the suspended matter and grease and the color. They would produce better results in regard to oxygen.

Q. That is to say, not knowing just what the results are that are stipulated in this agreement, you think it is likely they would produce better results?

A. Yes, I think that is fair.

Q. I understood you to say that you do not understand what the stipulation means with reference to the effect upon the oxygen of the waters?

A. Yes.

Q. So that when you say these other plants will produce better results in that respect, do you want to correct that a little?

A. Yes, I do not correct that. I show that I was referring only to the suspended matter and the grease and color.

Q. And in what respect, so far as you know, do the effluents with which you are familiar in these local sewage problems of sewage disposal, in what respect are they superior in results to those that are stipulated for in this stipulation which we are speaking of?

A. You are referring to the stipulations as to the results, not as to the methods?

Q. Always as to the results.

A. I have divided the stipulations as to results into two classes, one class being altogether satisfactory, if lived up to, and the other class being indefinite.

Q. There are some of them—I suggest to you in connection with the question I ask—which concern the party to the litigation, the party with whom the stipulation is made, the United States, and the sixth stipulation is the stipulation which concerns that party. You will observe that?

A. Yes.

Q. And the second stipulation—I direct your attention to that fact—deals with deposits with which the Secretary of War is concerned. Now, removing those from your consideration there are, as
I remember, two that you say are susceptible of being deter-
2466 mind definitely, or with reasonable definiteness as to whether they are being carried out or not?

A. Yes.

Q. And the other five?

A. The other three.

Q. The other three, yes. You think there is doubt about the ability to determine whether they are being lived up to or not?

A. Yes.

Q. Now, taking those other three, where do you know of another effluent produced from a disposal of a large city, which is to be preferred to the effluent which is stipulated for in this stipulation, provided it can be determined whether it is being lived up to?

A. Well, I find it very difficult to understand.

Q. Perhaps I better reframe my question. Prof. Winslow, assuming that all of the stipulations as to results are carried out in the sewage discharged from the Passaic Valley Sewer, and that whether or not they are carried out can be determined, in your opinion; upon that assumption will this sewage at the point indicated at Robbins Reef be objectionable or cause injury to the waters of New York Bay?

A. Why, yes, I think it will cause injury to the waters by exhaustion of the oxygen. In the first place, by the production of odors of decomposition at the point, and by the exhaustion of the oxygen of the harbor, which will cause a nuisance at other points.

Q. Now, I am asking you to assume that the stipulations will be carried out, and that there will be no odors in fact created by the discharge. Then, what injury do you anticipate in the waters from the discharge?

A. This is, you are assuming there is no suspended matter?

Q. Yes.

A. No color or grease?

Q. Yes.

A. No odors?

Q. Yes.

A. No reduction of dissolved oxygen?

Q. I have not asked that. I am asking now on the three.

A. Those are the four things. I should anticipate a reduction in the dissolved oxygen.

Q. Assuming that the stipulation as to the reduction of the
2467 dissolved oxygen in the seventh item of this stipulation as to results means that the oxygen will not be reduced by this discharge in the waters of the bay below a point of 70 per cent. in saturation, do you think that the discharge will be objectionable or injurious to the waters of New York Bay?

A. No, I should say not.

Q. Upon those assumptions, Prof. Winslow, are you testifying to the feasibility of establishing local disposal plants in the Passaic Valley, contemplating an effluent which is as high as that which is stipulated for in these stipulations?

A. No.

Q. And the effluent that you are contemplating for those municipalities or communities, into what waters do you contemplate that it shall be discharged?

A. Well, I have not gone into that. That would have to be decided by a study of the local situation. It might be by numbers of small plants discharging into the Passaic River, or it might be one large plant discharging into Newark Bay.

Q. Well, that one large plant discharging into Newark Bay, would or would not that be prohibitive by reason of its excessive cost?

A. I think not. There is no reason to suppose it would. Of course, I cannot say definitely without local estimates, but such plants are not prohibitive elsewhere.

Q. Have you familiarized yourself in any way with plans of the

Passaic Valley Sewerage Commissioners with reference to their disposal plant?

A. The disposal plant contemplated in this contract?

Q. Yes.

A. In a general way. I have not studied the drawings.

Q. But that is as you understand it, is it not, a combined plant on the Newark Meadows, in the neighborhood of Newark Bay.

A. No, I have not studied their plan for the Newark Meadows.

Q. You have not studied them so far to know whether or not they contemplate a central disposal plant?

A. No.

Q. Why did you say the cost of living up to those stipulations would be enormous?

2468 A. Because I am familiar with the general cost of sewage disposal plants and the only kind of plant that could produce results in accord with the literal meaning of these stipulations as to results would be intermittent sand filters, and they would be very expensive.

Q. It was not then because of a comparison of cost between individual local plants and one central plant that you testified that the cost would be enormous?

A. I testified simply to the cost of any process anywhere to produce the results indicated in the stipulation would be enormous.

Q. Because of the high character and excessive stringency of the standards of effluent that are set by it?

A. In certain respects, yes.

Q. And you think that it would be objectionable to discharge an effluent of that character into New York Harbor, whereas a lower standard could be properly discharged into Newark Bay, is that it?

A. No, that is not so.

Q. What is.

A. I said in certain respects the stipulations are prohibitive and absurd in regard to suspended solids and grease and color and it leaves the dissolved oxygen and putrescibility entirely inadequate.

Q. How do you know that?

A. Because they make no proper guarantees as to the putrescibility of the effluent, and they make an impossible promise in regard to the appearance of the effluent.

Q. As to the putrescibility that is, is it not, another form of saying they would destroy or absorb the dissolved oxygen in the waters?

A. Yes.

Q. Well, if you do not interpret the seventh item of this stipulation as fixing any standard?

A. No.

Q. Why, then, in that respect you are practically at a loss to know what the stipulation means?

A. Quite at a loss.

Q. So that you have got no standard before you upon which to measure the effect of this sewage in the waters of New York Harbor from these stipulations?

A. It seems to me that these stipulations fix no standard whatever

as to the oxygen or as to the putrescibility and that is what I mean when I say they are inadequate, and when I say they are unreasonably optimistic I am referring to what they say about suspended matter and color and grease.

2469

Q. And I think you have said that even though they were lived up to, these high standards as to suspended matter and color and grease, you would still think in your judgment that there would be or might be a high degree of putrescibility in this effluent?

A. Yes.

Q. Will you explain how that is possible?

A. Why, I tried to indicate those things. Crude sewage contains a large amount of suspended solids but is not particularly putrescible. *A*. If you pass that sewage through a sedimentation tank with a long storage period you remove the suspended solids and the effluent comes out clear, but is much more putrescible than it was to start with. Or again, compare the well known processes of sewage disposal. The effluent from a trickling filter is full of suspended solids. It looks afterwards like the sewage that went in at the top, but it is completely oxidized and non-putrescible. On the other hand, the effluent from a contact bed is often clear and practically free from suspended solids and highly putrescible.

Q. Now, Prof. Winslow, take the effluent which is clear and free from suspended particles, but is putrescible, and assuming that the proposed discharge at Robbins Reef from this proposed sewer is of that character, what in your judgment is the effect likely to be due to that cause?

A. A reduction in the dissolved oxygen in the harbor waters.

Q. And what, in your judgment, is the amount of the effect of that discharge in that regard upon the waters of the harbor?

Mr. O'Sullivan: The question is objected to on the ground that it is ambiguous.

The Commissioner: Note the objection of counsel for complainants.

A. I do not think I can answer that. I do not understand what you mean by amount of effect.

Q. What percentage of the dissolved oxygen in the waters of the bay would such a discharge in itself absorb?

2470

A. That would be quite impossible to say without two or three weeks' study of tidal flows and currents and varying conditions.

Q. You have not studied that?

A. No, I made no study of that.

Q. I thought you said you had studied the exhibits in this case?

A. I have.

Q. You have not made any special study of that?

A. The answer to that question involves a new study.

Q. And what injury do you say you would expect by the reduction of the dissolved oxygen in the Upper Bay from such a discharge at Robbins Reef?

A. I would expect a series of nuisances at all points in the harbor

where there would be a reduction in the dissolved oxygen. The waters that are on the right side of the critical line, a reduction in the dissolved oxygen which would push them over to the wrong side.

Q. Then you would expect, Professor, that where the city of New York is now discharging sewage into the waters of the harbor, with relative impunity by reason of there being a margin of dissolved oxygen to dispose of, that New York might be deprived of that margin by the presence of this discharge from the Passaic Valley Sewer?

A. Exactly.

Q. If New York was not discharging its sewage as it is now—which, I think you say you have observed?

A. Yes.

Q. But was adopting, employing methods of purification comparable to those that are specified in the stipulations which I have been asking about, do you think there would be any real injury by the reduction of the oxygen in the waters of the Upper Bay from the discharge of the sewage from the Passaic Sewer?

A. Referring now to the stipulations as to results?

Q. Yes.

A. No, I do not think there would.

Q. Do you know, Prof. Winslow, what the plans of the Passaic Valley Sewage Commissioners are at the present time?

A. No further than the general outlines set forth in the agreement and a general impression of the plan gained from the evidence.

2471 Q. Have you had submitted to you any evidence on the subject of what the present plans of the Passaic Valley Sewerage Commissioners are?

A. Not the plans in detail, no.

Q. Do you know what they plan to do with reference to industrial wastes?

A. No.

Q. In your opinion as to the effect of industrial wastes, are you or are you not assuming that all the industrial wastes of the district are to be discharged through this sewer?

A. I am assuming that.

Q. Would your testimony as to that feature of the case be in any way affected if it appears that the plan is to exclude all but ten per cent. of the industrial wastes of the district?

A. Why, yes.

Q. You do not know, as a matter of fact, that that is the plan?

A. No.

Q. You have testified as to conclusions based on certain float experiments. Were you present at any of those float experiments?

A. No.

Q. You did not see any of them?

A. No.

Q. Did you see the floats?

A. Yes.

Q. Do you know whether, as a matter of fact, the floats and the

float experiments corresponded in actual courses in the waters with the particles of sewage?

A. I see no reason why they should not.

Q. You think there is no difference in quality or character between the floats and sewage matter in suspension in the waters of a harbor?

A. Well, the commission used different types of floats, measuring the flow at different depths in the harbor. Of course, the course of the sewage would correspond more nearly to the shallower floats, as opposed to the wind action, rather than the deeper floats. As I understand, the floats measured accurately the movement of the water in which they were moving.

Q. You think they do?

A. I think they do, with reasonable accuracy.

Q. With reasonable accuracy. I think you testified as to certain conditions in the Hudson and East Rivers as bearable. Do you remember testifying to that expression in connection with those rivers?

2472 A. I think the conditions in the main channels are bearable. I think conditions in certain regions, I should find them unbearable.

Q. Where?

A. Gowanus Canal, Newtown Creek, the mouths of certain sewer outlets, in the Harlem and East Rivers.

Q. Where?

A. I do not remember now.

Q. Along the Manhattan shore?

A. Along the Manhattan shore mainly.

Q. And on the Brooklyn shore of the East River?

A. I do not remember any particularly bad point on the Brooklyn shore except the Gowanus Canal and Newtown Creek.

Q. Did you trace the source of pollution which caused the conditions at these points to be in your opinion unbearable?

A. In most cases I could see it coming out.

Q. Where?

A. From the mouths of the sewers.

Q. And what sewers?

A. I do not remember the names of the streets.

Q. Sewers from Brooklyn?

A. Sewer outlets from Brooklyn and Harlem.

Q. New York City?

A. Yes.

Q. Well, how long have you been familiar with those conditions?

A. Why, I suppose I have been familiar with the general conditions in New York for about fifteen years.

Q. Now, I think you have testified to certain dangers resulting from conditions of that sort, have you not?

A. Yes.

Q. Are you able to identify any danger which has demonstrated itself from the sewage which lies along the shores of Manhattan and Brooklyn in the Hudson and East Rivers?

A. No, I am not familiar with any evidence which traces disease to these sources.

Q. Now, where, in your observations, if you have observed, are harbor waters used by ships or in connection with the ships or shipping of the harbor?

A. I do not understand.

Q. Perhaps that is a little indefinite. You have testified to danger in using the harbor waters, in the use of the water upon ships?

A. Yes.

Q. Where were the ships when you saw them at the time
2473 when the harbor water was being used about the ships?

A. In the Bay, on small boats in different parts of the harbor, when a bucket of water was pulled up to wash the decks or for some purpose.

Q. Where else did you see the harbor water used for washing decks?

A. I do not think anywhere else.

Q. You never saw the water used in the slips when the vessels or ships were tied up to the dock?

A. I do not think I remember of having noticed it now.

Q. You cannot say whether they used the harbor water at those points for washing down the decks?

A. I never happened to see them doing it in the slips.

Q. It would be pretty bad water would it not?

A. Yes.

Q. So that the use of the water in that way and the dangers arising from it are, from your observations, rather inconsiderable, are they not?

A. I do not think the direct danger to health is great.

Q. Rather fanciful than otherwise?

A. I do not think it is fanciful. I think it is there, but small.

Q. Now, I think you have described the proposed discharge of the Passaic Valley Sewer as a solid body of sewage. Do you remember using that term?

A. I said or intended to say that the amount would be equivalent to a solid body of sewage 16 feet deep.

Q. When you used the word "solid" you do not mean it in the technical and scientific sense of a solid, do you?

A. No, I meant that it would make a compact mass of sewage, if it were all concentrated.

Q. If it were all concentrated it would be a body of sewage of some dimension which I think you have mentioned?

A. Yes.

Q. And that body would be, I suppose, of the same density that you have described to be the average density of sewage?

A. I did not testify to that. I did not give any figures.

Q. Perhaps you did not used the word density, it is lighter
2474 than harbor water. You testified to a certain percentage of sewage in harbor water, did you not?

A. Yes.

Q. What was that percentage?

A. About 800 parts of sewage matter in a million, average sewage.

Q. That is less than 10 per cent.?

A. No, 800 parts in a million is less than one parts in a thousand. About 1 part in a thousand.

Q. This body of sewage that you are referring to, will that, in your opinion, be different in all probability than the sewage that you have described?

A. No, I think not.

Q. So that when you speak of it as a solid body you are using the word "solid" in rather a loose way?

A. Perhaps so. I gave the total figures, according to my estimate, that number of tons of solid matter discharged there, in another place. When I used the word "solid" I think I meant simply a compact mass.

Q. Continuous?

A. A continuous mass.

Q. When it is discharged at the point at Robbins Reef and at the depth indicated, and by the distribution system that is indicated, you think that there will be established a continuous body of sewage of the dimensions that you have testified to?

A. No, I think that the mass will be under many conditions pretty nearly continuous at the surface, but it will not be continuous 16 feet down.

Q. It will be continuous at the surface?

A. I think that is likely.

Q. And to what depth?

A. That I cannot tell. As I picture that thing it will be—you will get there very much what you would get if you had 150 chimneys discharging smoke into a quiet air. The smoke will go up in funnel shape, as if you could conceive it outside of the chimney discharging into a closed *stace*, the smoke would be continuous.

Q. You have observed the effects of the discharge in Boston Harbor?

A. I have.

Q. From what population is that sewage collected?

A. Well, I would rather give you the amount of sewage.

Q. No, I would rather have you give the amount of population, if you can?

2475 A. I am not sure about that. The sewage is the sewage from the Mertopolitan District and I do not carry that figure in my mind.

Q. Well, is the actual sewage discharged equal to the amount that you are assuming in the case of the proposed discharge from the Passaic Sewer?

A. The amounts—quoting from memory—are about 100,000,000 from one outlet, and fifty at another and 30 at another, something like 180,000,000 gallons a day. The maximum flow at Robbins Reef in 1940, as reported, will be 350,000,000.

Q. Well, the flow at the present time, from the population of the district what will that be in your opinion?

A. That is on a population of 734,000. I should estimate the average there per capita flow as about 150 gallons. That would give about 100,000,000 gallons, a little over 100,000,000 a day. About the same as the flow from the present outlet at Moon Island, Boston.

Q. Well, is there a solid mass of sewage established in Boston Harbor of the dimensions that you have testified to as likely to result from the Passaic Valley Sewer?

A. I do not know how deep it goes, but there is a lake at the outlet of Moon Island, extending for two miles, at times, due to the discharge of the sewage, and at Deer Island, which is more comparable, the lake of sewage would probably extend a mile and a half. The other outlet is a smaller one and there the sewage area is at present small.

Q. You have measured the lakes of sewage, have you?

A. I have not measured them myself, but I am familiar with studies carried out by students, men, and by engineers of the Massachusetts State Board of Health, who have measured them, plotted them.

Q. Now, this solid mass of sewage that you have been testifying to as likely to result from the discharge of the Passaic Valley Sewer, is or is not that predicated upon the performance of the stipulations by the Passaic Valley Sewerage Commissioners in the character of the effluent discharged there?

A. It is not. It is based on the stipulations as to methods of purification.

2476 Q. It takes into account the specific stipulations as to methods, does it?

A. Yes, that question, as I remember it, assumed the sewage discharge and the sedimentation tanks and screens, nothing else.

Q. That is what it is based upon, is it?

A. Yes.

Q. Have you had a practical experience in the construction and operation of local plants for the disposal of sewage?

A. No. I have advised with authorities about the efficiency of plants, and have made extensive studies as to the purification of sewage in Boston, but I have done no construction work.

Q. When you expressed an opinion as to the feasibility of local plants in the Passaic Valley that was not based on any actual experience in construction?

A. No, that was based primarily on my knowledge of the subject as a student and a teacher, and on the careful examinations that were made on the general plans for the treatment of the Boston sewage.

Q. Based upon your knowledge that disposal and purification works are feasible, is it not, is not that all it is based on?

A. That they are feasible at a reasonable cost. Of course, it is my business as a student and teacher of sanitary science to take into account the cost data, and I am familiar with the expense. Also various processes as they are actually carried out.

Q. Have you made in that connection a study of the Passaic Valley?

A. No.

Q. Are you able to say whether individual disposal plants for each municipality would be more desirable from the financial point of view than a common disposal plant for the whole district?

A. That would not be known without a careful study of the local situation.

Q. So that you do not know anything about that?

A. No.

Q. You have not made that study?

A. No.

Q. Therefore, you would not be able to state whether, for the municipalities concerned, one general disposal plant at the Newark Bay would or would not be more advantageous to them individually than individual plants?

A. No.

2477 Mr. Riker: That is all.

Redirect examination by Mr. O'Sullivan:

Q. Prof. Winslow, are colloids found in sewage?

A. Yes, about a quarter of the organic matter present in sewage is often in the colloidal form, that is, in a form midway between solution and suspension.

Q. In the stipulation between the State of New Jersey and the Federal Government is any provision made there for the elimination of colloids from the sewage?

A. As I understand the terms of the stipulation, if there were no visible suspended particles, and if there was no color, there could not be any colloids, because you could not have those conditions realized unless you had practically a clear water. If there were colloids present they would add to the turbidity. I am using the term colloids in the sense that we commonly use it in sewage work, as meaning the very finely divided suspended matter. If that were present in any amount, I think the sewage would be visible as of different color from the water of the ocean.

Q. Is there any provision in that stipulation for the removal of matters in solution from the sewage?

A. No, so far as I can see it has no definite provision on that point.

Q. Are colloids and matters in solution, such as are found in sewage putrescible?

A. Yes.

Q. Mr. Riker asked you to assume that from this sewage to be discharged by the Passaic Valley Trunk Sewer odor would be eliminated, no suspended matter would be visible, no color and no turbidity, no matters in solution, no colloids.

Mr. Riker: I did not say colloids.

Q. No putrescibility, no depletion of oxygen saturation, would

that give you practically a filtered water, if such an effluent could be obtained?

Mr. Riker: The question is objected to on the ground that it does not state the facts asked by counsel for defendants.

The Commissioner: Note the objection of counsel for defendants.

2478 A. Such an effluent as that could only be produced, as far as I am aware by sand filtration, carried out at low rates.

Q. Is there any such provision in the stipulation to which I have called your attention, Complainants' Exhibit No. 135, for securing such an effluent?

A. No provision in the works stipulated for, no.

Q. Mr. Riker asked you to assume that if the stipulations are lived up to. I ask you if it is feasible to live up to these stipulations?

A. Except at very great cost of installing intermittent sand filters.

Recross-examination by Mr. Riker:

Q. You read this stipulation?

A. Yes, sir.

Q. When you say that the means for producing these results are not stipulated in this agreement, you mean they are not specifically described, do you not?

A. They are not stipulated for in the works described.

Q. You do not mean by that that they are not stipulated in the agreement itself?

A. Of course, that might be or might not be intended under lawful additional arrangements.

Q. You say might not?

A. I do not know whether they are or not.

Q. How is it possible that they might and at the same time might not be?

A. They are not excluded and they are not provided for.

Q. You say they are not included within requisite lawful additional arrangements, in your opinion?

A. I do not know whether they are or not. I doubt if anybody can now find out.

Q. Is it not possible leaving out of consideration the expense to adopt processes which will produce the effluent which is stipulated in this agreement?

A. Yes.

Mr. Riker: That is all.

Redirect examination by Mr. O'Sullivan:

Q. Do you know whether or not sand filters are lawful in New Jersey?

A. I do not. Pardon me, I know there are such filters. I do not know whether they are in violation of law or not.

Q. Does not that sentence call for a judicial interpretation of what means shall be lawful and what means shall not be lawful?

2479 Mr. Riker: The question is objected to on the ground that it requires expert testimony as a lawyer.

Mr. O'Sullivan: I will withdraw it.

At 1 P. M., adjourned to 2 P. M.

CORPORATION COUNSEL'S OFFICE,
NEW YORK, June 25, 1912.—Afternoon Session, 2 p. m.

JAMES H. FUERTES, a witness called on behalf of complainants, being first duly sworn, testified as follows:

Direct examination by Mr. O'Sullivan:

Q. Where do you reside?
A. Brooklyn.
Q. Where is your office?
A. 140 Nassau Street, New York City.
Q. What is your profession?
A. I am a civil engineer, civil and sanitary engineer.
Q. And where is your place of business?
A. 140 Nassau street, New York City.
Q. Where were you educated for your profession?
A. I am a graduate of Cornell University, College of Civil Engineering. graduating with the class of 1883.
Q. Have you been in the practice of your profession since that time?
A. I have been in continuous practice of my profession since that time. The early years after graduation were devoted to railroad and contract work in western and southern states. Since 1890 I have been in private practice as a civil and sanitary engineer, having had an office in New York City since 1895.

I have reported upon, designed and supervised the construction of works for the water supply, sewerage and improvement of the sanitary condition of about 100 cities in the United States and foreign countries.

2480 Q. State some of the most important?

A. Among the most important of these works may be mentioned the following:

An investigation and report on the improvement of the sanitary condition of the City and Port of Santos, Brazil, made in conjunction with the late Professor E. A. Fuertes, and Ma. Rudolph Hering. This covered the questions of sewerage, sewage disposal, harbor protection, swamp drainage and the disposal of storm water in the city, quarantine, cleaning of the city, methods of refuse disposal, improvement of the water supply and the establishment of conditions to rid the place of Yellow fever and smallpox.

I have reported upon the improvement of the water supplies of New York City, Harrisonburg, Pa., Philadelphia, Pa., Steelton, Pa., Parkersburg, W. Va., Charleston, S. C., Winnipeg, Canada, Cumberland, Md., Lynchburg, Va., Plainfield, N. J., Caracas, Venezuela, and many other cities, and upon the sewerage and sewage disposal of

Harrisburg, Pa., Lebenon, Pa., Ithaca, N. Y., Alexandria, La., Para, Brazil, Caracas, Venezuela,; Orange, Montclair, and East Orange, N. J., Hackensack, N. J., and many other cities, and have built many other important engineering structures, including a large reinforced concrete arched viaduct, nearly one-half mile long in Harrisburg, Pa., a high concrete arched viaduct on "D" street, Lynchburg, Va., and a concrete arched viaduct on Fifth Street, across the tracks of the Boston and Maine and N. Y. N. H. & H. Railroad tracks and Nashua River, in Fitchburg, Mass., which latter work is under construction.

I have built and put in operation an entire new gravity water supply for Lychburg, Va., a municipal water filtration plant for the City of Harrisburg, Pa., and one for the City of Steelton, Pa., many miles of sewage of various sizes in the City of Harrisburg, and important flood prevention works in that city.

I have three times visited Europe to study and keep posted on European methods of sewerage, sewage disposal, water supply
2481 and water purification, and have made many examinations of the principal municipal plants of this nature in Europe and have three times visited South America to report on sanitary matters and have visited and inspected most of the principal European seaports and harbors.

Q. State some of the societies that you belong to in connection with your profession, and what publications you have been the author of and contributed to the literature of your profession, and state any honors that have been conferred upon you by your profession?

A. I am a member of the American Society of Civil Engineers, and of the American Water Works Association, and have published many papers and reports on sanitary subjects, including a book on water filtration works, and another on water and public health, both of which were published by John Wiley.

Q. Did you ever receive any distinction for your work in your profession?

A. In 1907 I was awarded the Fuertes Medal by Cornell University for original research in engineering work.

Q. What present position do you hold?

A. I am at the present time engaged as consulting engineer by the City of Harrisburg, for the construction of an intercepting sewer along the river front past the city, for the construction of a dam across the Susquehanna River, at Harrisburg, and for the improvement of the sanitary condition of the Susquehanna River front past that city. I am also at the present time building sewage disposal works for the City of Lebanon, Pa., and Newark, N. J.; am building a gravity water supply for the City of Cumberland, Md., the contract for which was awarded last summer, am supervising the construction, from my plans, of the Fifth Street Viaduct in Fitchburg, Mass.; am reporting upon the water purification of the City of Dallas, Texas; am consulting engineer for the City of Plainfield, N. J., in the matter of its improved water supply, and of the township of Cranford, N. J., in the matter of its water supply, and sewage purification, and for the City of Hoboken, N. J., in the matter of its

sewerage and sewage disposal; am preparing plans for the
2482 sewerage and sewage disposal of Newark, N. J.; and am acting as consulting engineer for the City of Oswego, N. Y., in the testing of its new water works intake pipe.

Q. When were you appointed to the Metropolitan Sewerage Commission; how long have you been a member?

A. I am a member of the Metropolitan Sewerage Commission of New York, having been appointed by Mayor McClellan November 5, 1906, and having served continuously until the present time.

Q. In what capacities have you served on this Metropolitan Sewerage Commission of New York?

A. I have been a member of the commission since November, 1906, and have acted as secretary since January, 1908.

Q. What have been your duties as secretary?

A. The duties of the position of secretary are not prescribed in the Act creating the commission, but it has been my business to attend the meetings of the commission, to keep the minutes of the meetings, to keep track of the commission's finances, to serve on the committee editing the publications of the commission and on special committees.

Q. Can you state what appropriations have been made for the use of the Metropolitan Sewerage Commission and how this money has been expended?

Mr. Riker: The question is objected to as immaterial and irrelevant.

A. Since the 12th of June, 1908, which was the first appropriation that was made to the commission after it reorganized, the appropriations have been as follows:

Metropolitan Sewerage Commission of New York.

Corporate stock. Date of authorization.	Amount authorized.	Allotted. Par value.	Allotted. Premium.	Total.
June 12, 1908	$75,000	$75,000	$616.12	$75,616.12
" 3, 1910	29,000	29,000	45.53	29,045.53
Dec. 1, 1910	31,000	31,000	286.82	31,286.82
July 7, 1911, ...	34,000	29,000	(to date)	$135,948.47
March 7, 1912 ...	20,000			
	$189,000			

Total expenditures from June, 1908, to June, 1912, $158,889.21.

2483 Q. How many meetings has the commission held since its organization in 1908?

Mr. Riker: The question is objected to as immaterial and irrelevant.

The Commissioner: Note the objection of counsel for defendant.

A. In 1908 the commission held 45 meetings; in 1909, 53 meetings; in 1910, 53 meetings; and in 1911, 57 meetings.

Q. How often are the commission's meetings held?

Mr. Riker: The same objection.

The Commissioner: Note the objection of counsel for defendants.

A. The regular meetings are held once a week; special meetings as to the exigencies as the work demand.

Q. What is the nature of the business transacted at these meetings?

Mr. Riker: The same objection.

The Commissioner: Note the objection of counsel for defendants.

A. The minutes of the previous meetings are read, bills and payrolls are presented for approval at the proper times, the policy of the commission discussed in relation to matters which come up, the work that has been done during the past week, or is to be done, are discussed, and problems of future work agreed upon. When any portion of the work has been completed by the commission's force the results are laid before the commission immediately for discussion, amendment or adoption. The commission, as a whole, acts on all matters of importance. All reports that are brought out are sent to the members for study, suggestion and corrections before adoption by the commission, and the final reports represent the views of the commission as a whole.

Q. What plan was followed by the commission with regard to special investigations?

Mr. Riker: The same objection.

The Commissioner: Note the objection of counsel for defendants.

A. Committees are appointed in certain cases to collect and
2484 present to the commission data relating to different subjects.

Q. What special committees have been appointed for the purpose of making such studies?

Mr. Riker: The same objection. And the further objection that this body is not a party to this controversy and matters occurring in it are hearsay matters.

The Commissioner: Note the objection of counsel for defendants.

Q. What do you say as secretary of the commission?

A. Since 1908 the more important committees have been the following:

Committee to collect data regarding population and sewage statistics, appointed in March, 1908.

The Tidal Committee, appointed in June, 1908.

The Committee on Harbor Water and Diseases, in July, 1908.

The Committee on Population and the Discharge of Sewage, in October, 1908.

The Committee on the Pollution of Harbor Waters and their relation to diseases, in October, 1908.

The Committee on the Quantity of Street Wastes finding their way into the sewers, in January, 1909.

The Committee to consider intervention in the Passaic Valley suit, in March, 1909.

Tidal Committee, re-appointed in June, 1909.

Committee on Population and Sewage Flow, in June, 1909.

Committee to inspect the condition of the harbor waters, in July, 1909.

Committee on present methods of the collection and disposal of sewage in the Metropolitan District, in October, 1909.

Committee on Harbor Water and Public Baths, in November, 1909.

Committee on Publications, in November, 1909.

Committee on the Circulation of Water in the Harbor, in July, 1910.

Several of these committees have been continued and are still in office.

2485 Q. Upon what special committees have you personally served?

Mr. Riker: The same objection.

The Commissioner: Note the objection of counsel for defendants.

A. The Committee on the present methods of collecting and disposing of the sewage in the Metropolitan District. The Committee to inspect the conditions of the harbor waters. The Committee on publications, which edits all the publications of the commission.

Q. Of what did your work consist on the Committee on the present methods of collecting and disposing of sewage in the Metropolitan District of New York City?

Mr. Riker: The same objection.

The Commissioner: Note the objection of counsel for defendants.

A. I collected, arranged and put in form for record all the available data, some of it personally and some of it through the commission's assistants, relating to the sewage systems of all the cities and towns in the Metropolitan District as outlined by the Metropolitan Sewerage Commission. An abstract of these data is published in the report of the Metropolitan Sewerage Commission of April 30, 1910, from page 217 to page 361, inclusive; these descriptions cover the essential facts relating to the sewerage and sewage disposal of some forty cities and towns having an aggregate population of over 5,000,000 people. The portions of the April 30, 1910, report, above referred to, as well as the portions from pages 51 to 59, and 85 to 120, inclusive, were written by me, and the entire report was edited by me in collaboration with the President of the Commission.

Q. Can you state in brief terms the essential features of the sewerage and sewage disposal works of the Metropolitan District?

Mr. Riker: I object to the question on the ground that the existing sewage disposal works of the Metropolitan District have no rela-

tion at all to the issue in this cause and that the question calls for matter which is immaterial and irrelevant.

2486 The Commissioner: Note the objection of counsel for defendants.

Mr. Riker: It is further objected to on the ground that this witness has not been qualified by showing his knowledge.

The Commissioner: Note the further objection of counsel for defendants.

Q. You may proceed.

A. This subject is almost too large to describe offhand and I had expected to read in the description of this from the pages of the report referred to, that is, pages 85 to 88, down to Section 2, page 90, beginning with the last paragraph, and on page 91, 92, 93, 94, 95, 96, 97, 98 and 99, to Section 5. That contains a description of the general features of the Metropolitan District.

Q. In that report of the Metropolitan Sewerage Commission?

A. In the report of the Metropolitan Sewerage Commission, April 30, 1910.

Q. Have you a map that would show the location and sizes of the principal sewers and sewerage systems discharging into the harbor waters?

A. I have not that map here. The map is not yet prepared. It was made up in sections, but it has not been compiled into a map.

Q. Mr. Fuertes, has the commission ever as a body or as individuals visited other cities to investigate their sewage problems, using such knowledge on the work of the Metropolitan Sewerage Commission for their guidance?

Mr. Riker: The question is objected to, as it calls for an answer that is immaterial and irrelevant.

The Commissioner: Note the objection of counsel for defendants.

A. Yes. On May 6, 1908, the Metropolitan Sewerage Commission visited the city of Boston, and in company with Mr. William M. Brown, Engineer of the Sewerage Works of the Metropolitan Water and Sewerage Board, made an inspection of the Boston Harbor, and of the outlets of the sewer at Nut Island, Moon Island and Deer Island. On May 25, 1908, I personally called upon Mr. O. H. Tittman, superintendent of the United States Coast and Geodetic Survey, in Washington, in connection with the tidal work done by the United States Government, and secured for the use of

2487 the Commission several documents which had been published by the Coast Survey. On January 7, 1911, the commission sent its president to Europe to study the pollution of various European harbors, and investigate and report upon methods of sewage purification which had been recently developed.

Personally I have visited all the different cities and towns in the Metropolitan District, and have inspected the sewer outfalls into the harbor waters and have on various occasions observed the condition of the water in the harbors of other cities, including those of London, Liverpool, Hamburg, Southampton, Marseilles, Genoa, Rio

de Janeiro, Para, Lisbon, and Queenstown, abroad, as well as several harbors of American cities, including those of Boston, New York, Philadelphia, Charlestown, S. C., and Bridgeport, Conn.

Q. Have you made any inspection of the sewage in the waters of New York and other harbors?

A. I have made several such inspections, as follows: On May 6, 1908, Commissioners Soper, Parsons, Sooysmith, Williams and I met Mr. William M. Brown, Engineer of Sewerage Works of the Metropolitan Water and Sewerage Board, at the Parker House, Boston, Mass., Wednesday, May 6, 1908, and went with him to visit the outlets of the main sewers of Boston at Nut Island, Moon Island and Deer Island.

The party had a chartered tug and went first to the Nut Island outlet. At this outlet the sewage is discharged into the harbor, about one-half mile west of Peddocks Island, and something over a mile north of Nut Island at a point where there is a very strong tidal flow and deep water.

The Nut Island outlet receives the sewage from the south Metropolitan area, which has a population of approximately 400,000 people. The works were put in operation in 1904, and the average total discharge of sewage, when first built, was about 25,000,000 gallons daily; the quantity has now increased to about 40,000,000 gallons per day with a maximum of 97,000,000 gallons. The main outfall sewer is 11′ 3″ by 12′ 6″ in dimensions, being split
2488 into two parellel 20-foot sand deposit sewers just before reaching the screen house on Nut Island. These sand deposit sewers are seldom cleaned, it being a difficult and dirty job; no offense yet observed from allowing the deposits to scour out naturally. The sand deposit sewers were added to the original plant at the instance of the State Board of Health, who also required that the elevation of the sewer, at the screen house, should be sufficiently high to enable the sewage to be delivered into a tidal storage reservoir to be located on Peddocks Island in case the Board of Health should require the intermittent discharge of the sewage, at some future time, instead of the continuous discharge which was contemplated and is now in force. The storage reservoir has not been built.

The screen house at the termination of the sand deposit sewers contains two sets of double screens, and a forebay from which five 5-foot outlet pipes are ultimately to lead out under the bottom of the harbor and discharge the sewage at different points. At present only two of the 5-foot outlet *piles* are built, and these are used alternately.

The screens are operated by steam engines and winches mounted upon the frames in which the screens are elvated, each pair of screens being operated by one engine with a clutch arrangement so designed as to enable the four screens to be handled with two engines. The screens proper are three sided cages constructed of 3/4-inch bars standing vertically. The screens are about 10 feet long, about 8 feet high and about 2½ feet wide, with a perforated plate for a bottom. For the first 3 feet in height the vertical screen

bars stand in two rows about 7/8 of an inch apart, in the clear, the bars being staggered, one behind the other, so as to show a clearance of about 1/8-inch when viewed from behind. The upper portion of the screen area has single bars only, 3/4-inch diameter and spaced about one inch apart in the clear.

The screens have to be raised about once an hour for cleaning, which operation is accomplished by sweeping the screens down vertically with a stable broom, and then dragging the screen-
2489 ings inward upon the floor of the screen with a tined fork.

The screenings, which consist principally of shreds of paper and rags, with fruit peelings, and similar matters, are shovelled into a cider press where the water is squeezed out of them and runs down, to a sewer below, through a hole in the floor. The partially dried screenings are burned in the fire box of the steam boilers. The screenings amount to from 1 to ½ cubic feet per million gallons of sewage passing through the station, the average analysis being 90% paper, 5% rags and 5% fecal and miscellaneous matter.

The control gates to the 5-foot outlet pipes are operated by hydraulic cylinders.

A recording tidal gauge and stationary float gauge show the operating conditions at all times.

The 5-foot cast iron pipes forming the outfall sewers were laid upon the bottom of the harbor. The pipes were jointed in 50 feet lengths above the water and then lowered down to the bottom. Joints between the 50-foot sections were made by using a taper and spigot, leaded in to a bell end, the joints being made above water and then pulled apart, and the taper end re-entered into the socket under water and caulked cold by a diver. The cost of these pipes was about $30.00 per foot each laid.

The outlet end consists of a 1/4-bend discharging vertically. It was surrounded by piles and the space around the pipe and piles filled with stones and rip rap as a protection. Immediately over the outlet, which we saw at low tide, the sewage boiled up like a large spring, the agitation being quite violent over a circular area with a diameter of perhaps 15 feet. The odor was noticeable before we had approached nearer than within 500 or 600 feet of the outlet, but was not very offensive; it was not very offensive even when close to the outlet on the lee side. The discoloration was not great, the water having a somewhat grayish appearance; floating matter was plentiful and consisted of little balls of grease, particles of scum, and shreds of paper which could be seen several hundred
2490 feet away from the outlet in all directions; on the lee side of the outfall, one thousand feet away. The "sleek" on the surface of the water was plainly noticeable for at least a mile in the direction in which the tide was running at the time.

Before we had approached the end of the outlet its position was indicated not only by the smooth appearance of the water but by the flock of gulls which hovered over it.

The discharge at this point takes place under 30 feet of water (low tide) and the vertical ascension insures a fairly good disper-

sion of the floating matter and sewage before it reaches the surface. Mr. Brown stated that he considered the depth at which the discharge takes place a very important factor in securing a satisfactory dilution.

After leaving the Nut Island outlet the Board proceeded to the outlet at Deer Island where the sewage from the north Metropolitan area is discharged. The population tributary to this outlet is stated by Mr. Brown as about 450,000, the average daily discharge being at the present time 50,000,000 gallons, and the maximum 150,000,000 gallons. The outlet at this point is located at the Deer Island lighthouse, the discharge being upon the surface of a half-tide gravel bar. The offense is much greater at this outfall than at the Nut Island outfall, due to the much shallower water, and to the discharge of the sewage near the surface of the water. At the time of our visit the sewer was discharging under about 3 feet of water. At high tide it is submerged to about 7 or 8 feet and the waters sweep across the bar and produce a much greater dilution than was obtaining when we saw it. The ebullition was considerable, but not so strong as at Nut Island, the fault at the latter point being the result of having to keep the invert high in order to get the sewage across to the proposed reservoir on Peddocks Island.

The screening at the Deer Island Pumping Station, which we visited also, was not as thorough as at Nut Island, particles at least an inch in diameter readily passing the screens. The pumping machinery at the Deer Island Pumping Station consists of
2491 40,000,000 gallons Allis-Chalmers horizontal centrifugal pumps driven by a 3-cylinder Corliss valve engine, the cylinders being placed at angles of 60 degrees. The lift is about 7 to 17 feet, depending on the stage of the tide. The plant is beautifully kept up.

The sewage field at the Deer Island outlet extended for perhaps a mile toward South Boston, and varied in width up to perhaps one-half mile, as indicated by the "sleek" on the surface.

After leaving Deer Island the Board proceeded to the Moon Island outlet, at which point the sewage of the Boston Main Drainage Works is discharged. These works were built in 1884, and are fully described in Mr. E. C. Clark's report on the Main Drainage Works of Boston. At the present time the discharge of sewage averages 80,000,000 gallons per day with a maximum of perhaps 150,000,000 gallons. The sewage is received on Moon Island in four storage reservoirs holding altogether 50,000,000 gallons. In the original plant the storage capacity was 25,000,000 gallons.

The main outfall sewer comes down to the plant across the west side of the storage tanks; and directly beneath this sewer is a second, which leads to the outfall in the harbor. Over these two sewers stands a long gate house which contains a horizontal shaft running its whole length and carrying gear wheels and clutches which engage in cog wheels on the vertical shafts of the gates controlling the openings of the upper and lower sewers. Recently, a branch sewer has been built leading from the upper sewer eastward to the back end of the tanks and then northerly across the farther ends

with a gate house in each tank, the object of which is to permit turning raw sewage into the tanks at the farther end for the purpose of flushing the bottoms out after the tanks have been emptied. There is practically no accumulation of grease or decomposable matter upon the rough stone masonry of the sides of the tanks. The odor was not particularly strong, being the characteristic greasy, musty odor of sewage not yet badly decomposed. All the
2492 gates admitting sewage to the storage tanks, and discharging it from the tanks to the outlet sewer, are operated by a turbine wheel which derives its power from the sewage falling from the upper to the lower sewer. The gates in the flushing chambers on the east ends of the tanks are operated by compressed air, a small compressor and air receiver, with an automatic gasoline engine for reserve power, being located in the gate house.

The outfall sewer consists of two parallel channels 10, 10″ X 12′ 0″ leading to a bulkhead on the north shore of Moon Island at its northwest corner.

The sewage is discharged as rapidly as possible from the storage tanks one hour after high tide, the discharge requiring nearly an hour for its accomplishment. When discharging the full quantity the discolored water reaches out to the shores of Long Island, and covers an area of perhaps one thousand acres as a maximum. It is said that two hours after the discharge no traces of sewage are visible in the vicinity. Numerous examinations of the bottom of the harbor near the outlets have been made by the State Board of Health and by the Sewerage Commission, and these have failed to reveal any accumulation of sludge or sewage matter on the floor of the harbor.

The discharge of sewage from this outlet is an interesting example of the spreading out of the sewage upon the top of the salt water without much mixing, the division line between the sewage and the clear sea water remaining very sharp and definite for some time around the entire area into which the sewage is discharged.

The waters of the Boston Harbor are very beautiful and clear in the upper harbor, and at a distance of a mile or so away from any of the sewer outlets. Mr. Brown stated in response to an inquiry that——

Mr. Riker: I shall move to strike out that testimony.

Mr. O'Sullivan: Omit what Mr. Brown said. Who was Mr. Brown?

The Witness: The Chief Engineer of the Metropolitan Water and Sewerage Board of Boston.

2493 Q. And he is now with the Passaic Valley Sewerage Commission?

A. So I have heard.

Q. Mr. Fuertes, did you make any inspections of the Lower Bay, Gravesend Bay or Jamaica Bay at the time, and if so, state what your tour of inspection consisted of?

A. On July 6, 1909, Commissioner Soper and I made an inspection of Lower Bay, Gravesend Bay and Jamaica Bay as follows: In passing through the Upper Bay on the "Hattie Bell," the commis-

sion's launch, it was noted that some of the beaches and wharves where public bathing is customary, were in the immediate neighborhood of large sewer outlets, notably those in the neighborhood of Fort Hamilton. Two of the new sewer outfalls in this neighborhood are carried out a long distance from the shore, being constructed of concrete, presumably on pile foundations, and protected by piles and timbers. The tops of the sewers extend above high tide from the shore line to their mouths, and the sewage discharged therefrom is consequently drawn around in the eddy formed by the swirling water rushing into and out of the harbor under tidal influence, and sewage and floating matters collect in the lee of the obstructions so formed. Bathers were observed swimming around in the water at these places surrounded with visible evidences of sewage discharge. The same is the case in Gravesend Bay at Bath Beach and Ulmer Park, the conditions being unsanitary and dangerous. The danger at these points could be largely reduced by extending submerged outfalls to deep water, so that the clean water of the inflowing and outflowing tides would pass between the shore and the ends of the sewers to disperse and dilute the sewage and not drive it to the shores, in eddies as in the case with the existing outfalls.

The beach at Nortons Point near Sea Gate was littered with driftwood, garbage and other floating refuse which had been raked in piles to be disposed of by burning. The practice of burning is limited to days on which the wind blows from the east in order that the offensive odors may be blown away from the residential sections of Sea Gate.

2494 Passing out past Coney Island and the beaches a large field of floating grass, sticks and other debris was encountered; this evidently had been dislodged from some of the meadows or grass flats in Jamaica Bay by the exceedingly high tides of the previous day. The wind was blowing freshly from the south and the tide, though falling, was still high, a stiff outward flow being encountered at the entrance to Jamaica Bay. Passing along near the north shore of Rockaway Point a few small sewer outfalls were noted discharging upon the beach, at none of which was there apparently an aggravated nuisance. Back of Arverne, however, the canal into which the sewage of this section is discharged was exceedingly foul. The water was not only black and ill smelling, but contained visible evidences of sewage in all stages of decomposition. Immediately in front of the mouth of one of the larger sewers of Rockaway, men and boys were digging in the mud for soft clams, while a little further out in the direct line of the discharge of the canal carrying the Arverne sewage other men and boys were clamming with tongs and rakes. On both sides of the causeway at Rockaway and on both banks were stakes indicating oyster beds.

In passing Barren Island it was noted that the smoke from the chimney at the reduction works, while not dense as it issued from the chimney, and not of extraordinary great volume, was spun out by the wind into a long cloud which could be traced distinctly for

probably over five miles towards Brooklyn. This streak of smoke apparently remained at about the same elevation above the ground for the whole distance, and demonstrated the slowness with which dispersion may take place in the air, a very elastic medium; and indicated how imperfect the dispersion might be from large submerged sewer outfalls into a moving body of water.

After an inspection of the conditions at Rockaway, the members of the Commission returned to Brooklyn by train.

Q. Did you, Mr. Fuertes, conduct an inspection of the harbor waters at Rockaway Beach or Canarsie or Jamaica Bay, in addition to the ones you have just described?

2495 A. I did. On July 12, 1909, Commissioner Soper and I made an inspection of the harbor waters from Rockaway Beach to Canarsie, and thence out through Jamaica Bay to Sandy Hook and the east shore of Staten Island, as follows: It was decided best not to undertake a detailed examination of the small creeks discharging into Jamaica Bay to the east of Canarsie on this occasion, as this could be done with greater economy of time by starting the inspection from Canarsie in a small launch or rowboat, than from the "Hattie Bell," on which the general inspection was made. The attention of the commissioners, therefore, was directed to the general conditions obtaining in the neighborhood of Canarsie with reference to the likelihood of the pollution of the oyster beds and clam fisheries in that vicinity.

The odors at the wharf at Canarsie were distinctly disagreeable and characteristic of decomposed sewage. At this point sewage is carried back and forth under the wharf and along its front line by the oscillatory motion of the tides, the sewage from Bergen Beach traversing considerably to the east of Canarsie and the sewage from the creeks east of Canarsie travelling possibly to the west of Bergen Beach. It was deemed proper, in view of local conditions, to undertake the carrying out of float observations in the Jamaica Bay waters to determine the currents and the points to which sewage matters would be carried by the tides.

In a general way the waters of Jamaica Bay appear to be, where not subject to direct sewage pollution, fairly clear and in an inoffensive state, although considerably more turbid and discolored than the clear water of Long Island Sound.

Passing Barren Island the waters in the immediate neighborhood of the shores were somewhat offensive due to the discharge of the wastes of the horse factory and the garbage disposal works.

On the way to Sandy Hook from the entrance to Jamaica Bay little was observed in the shape of litter and floating matters,

2496 as the tide was rising at the time and the current consequently landward. On reaching Sandy Hook the clam fisheries were inspected, although, not in much detail, owing to the prevalence of fog. At a point about half way between Sandy Hook and the shore of Staten Island at Midland Beach evidences of sewage from New York City were visible, quantities of lemon peels, oranges, burnt matches and other similar matters being distributed over the water

too generally to permit their being accounted for by their discharge from vessels and boats passing in and out of the harbor.

It had been the intention, in passing the Staten Island shore, to inspect the oyster beds, but the weather was too heavy and the fog too dense to make this feasible.

Q. Did you at any time make a tour of inspection of the oyster beds and fisheries along the east shore of Staten Island and in the Kill von Kull, and if so, state what your inspection consisted of?

A. On July 19, 1909, Commissioner Soper and I made an inspection of oyster beds and fisheries along the east shore of Staten Island and in the Authur Kill as follows: The "Hattie Bell" proceeded down the bay through the Narrows and along the east shore of Staten Island, stopping for a few moments opposite South Beach for the purpose of inspecting the gasoline launch which had been offered to the commission. The launch, however failed to appear and the party then proceeded to the oyster beds, which cover a very large territory and reach from about opposite Elm Tree Beacon to Tottenville.

Apparently the waters in which these oysters are planted are fairly clean and unpolluted, as no evidences of sewage or city wastes were visible in that neighborhood during this trip.

On reaching Tottenvillle the President disembarked and returned to New York, the launch, with Commissioner Fuertes, proceeding up through Arthur Kill to inspect the natural oyster beds in the neighborhood of Rossville, and observe the conditions in the Arthur Kill, where the Rahway River discharged into it, and also where the sewer for the Oranges discharges into it at Elizabethport.

2497 The water in the Arthur Kill was decidedly turbid throughout practically its entire length, and was more or less offensive at many places, particularly at the mouth of the Rahway River, around the piers of the Phosphate and Chemical works near Rossville and Linoleumville, and near the crossing of the Baltimore and New York Railroad.

The discharge of the sewer at Elizabethport takes place at the surface of the water, at the shore line, and occasions considerable discolorination and odor. A short distance out from Elizabethport, however, in Newark Bay, the visible effects of pollution from this sewer had disappeared by dispersion.

Oysters were being dredged, by hand, from the Arthur Kill opposite Fresh Kills, and one boat was also observed oystering in the Lower Bay near Great Kills.

The waters of Kill von Kull appeared to be in fairly good condition, but the wind was blowing so hard that the waves destroyed any evidences of pollution which might otherwise have been visible.

Q. Did you make an inspection of the conditions in the East River at any time, and if so state under what conditions you made the inspection, and with what results?

A. On September 27, 1909, Commissioners Soper, Parsons, Williams and I made an inspection of conditions in the East River. The "Hattie Bell" proceeded from the Battery to Pier 34, East River, following the Manhattan shore line. The tide was running out

strongly at the time and was about ¼ ebb by the time the launch reached Pier 34. At this point about one pound of uranine, dissolved in a bucket of water, was thrown overboard and followed down stream by the launch for a distance of about half a mile, the experiment being repeated with special scarlet in order to enable the members of the commission to observe the relative conspicuousness of these two dyes under the prevailing conditions.

In both instances the discolored areas moved toward the south with a slight tendency to be drawn out to the center of the river;
2498 the passage of numerous boats through the discolored areas and along their margins, however, soon scattered and dispersed them through eddies until it was no longer profitable to follow them.

The launch was then turned, and, following the Manhattan shore, entered the mouth of the Harlem River, the party disbanding at the crossing of the Third Avenue elevated railroad.

The offensive conditions prevailing between the Manhattan shore and the shore of Ward's and Randall's Islands, noted on previous inspections, prevailed on this occasion, though possibly they were not quite so extreme owing to the large amount of sea water entering the river from Long Island Sound and more or less diluting the sewage. The most offensive conditions were in the neighborhood of the 110th Street sewer, where the water had the characteristic odor of strong sewage, was a light, opaque-gray in color and was filled with shreds and masses of sewage, the origin of which could be easily recognized. The Harlem River was on this occasion not so offensive as the main river in the neighborhood of 110th Street; still it was in a very unwholesome and unsavory condition.

Before entering the Harlem River the "Hattie Bell" was anchored at a point about opposite the center of Ward's Island and about 50 feet out from the shore, and a quantity of uranine was discharged from the tank on the boat through a 2-inch hose, the end of which was about 20 feet below the surface of the water. Within a couple of minutes after the pump was started the uranine appeared at the surface a short distance from the boat and in line with the current prevailing at the point where the hose discharged.

Q. Did you made any tour of inspection of the shore line of Manhattan from the Battery up along the Hudson River at any time, Mr. Fuertes, and if so state what your inspection consisted of, and with what results you were rewarded?

A. On September 29, 1909, Commissioner Soper and I made an inspection of the shore lines of Manhattan from the Battery nearly to Yonkers. Starting from the Battery with the "Hattie
2499 Bell" the conditions along the shore front as far as Pier 25 were in many instances extremely offensive, and throughout the whole distance there was no time when visible evidence of sewage and matters of sewage origin could not be seen anywhere between the pier head line and a line 200 to 300 feet out into the river. In some places the evidences of fresh sewage were distinctly apparent, and in some of the slips the water was in a very foul condition. The tide was running out and was about ¼ ebb.

The conditions appeared to be particularly bad at Pier 25, Pier 21, 32, 40, 51, 54, 59, 61 and at 23rd Street and 48th Street. At the docks where the Red Star, White Star and Hamburg-American Lines of ocean steamers lie, where several of the night steamboats that ply the Hudson River and Long Island Sound berth, the sewers discharge into the slips in such a manner as to form a decided nuisance. In some places the odor was almost nauseating, although the conditions as to temperature, humidity, etc., were not such as to foster active decomposition. It would seem to be almost a certainty that vessels lying in these waters would be permeated with the foul odors by which they are surrounded. Opposite Pier 32 the sewage formed a very opaque stream about 20 feet wide, more or less, and the water was covered with floating matter and garbage. The sewage coming from under Pier 40 was very black and particularly malodorous. The worst odors were in the neighborhood of the sewers coming out from under Pier 61 at the White Star docks.

When opposite the mouth of Spuyten Duyvil Creek, about four to five miles below Yonkers, the sewage of that city was plainly discernible over a strip extending from the shore out for several hundred feet into the river. On approaching Yonkers the width of the discolored strip decreased somewhat, but the intensity of the pollution increased rapidly, and at a distance of from three to four miles below the city evidences of fresh sewage were to be seen on every hand, the water being filled with charasteristic discharges and possessing the filthy, greasy odor characteristic of stale sewage.

2500 At the time of this inspection the fleet of the American and foreign warships assembled in these waters to take part in the Hudson-Fulton Celebration was lying at anchor between 42nd Street and Spuyten Duyvil Creek. No statistics were at hand relative to the population of these vessels, but, counting the persons on the pleasure boats and other craft, must have reached possibly 15,000 to 20,000 people. The warships were lined up so that they were all in practically the same current, and it was interesting to note in the water the considerable evidences of the sewage and wastes from these vessels.

As the "Hattie Bell" passed one of the vessels some of the sailors dumped over a large canvas full of potatoes and potato peelings, possibly a couple of barrels full. Similar practices were followed, undoubtedly on the other vessels, and a great deal of floating litter was observed in the neighborhood in corroboration of this.

After passing the fleet of warships the launch proceeded to the dock at Mt. St. Vincent to give the Commissioners an opportunity to observe the point where the Bronx Valley Sewerage Commissioners proposed to locate the outlet of the proposed Bronx Valley sewer. There were signs of considerable activity about this project, a large amount of pipe intended for the outfall being piled up along the river bank alongside the railroad. It was interesting to note that at the point where the proposed sewer is to terminate the water in the Hudson River was already intensely polluted with the sewage of Yonkers, the river water instead of being transparent and clear being opaque and of a dark brown color for a distance of at least 200 to 300

feet from the shore on this occasion, and the surface having the characteristic greasy sleek observable at large sewer outfalls.

Q. Mr. Fuertes, did you undertake an inspection of the Manhattan and Brooklyn waterfronts of the East River and the waterfront along the Borough of the Bronx as far as City Island, at any time, and if so state with what results?

2501 Mr. Riker: One moment. Before continuing I observe you are using a memorandum, Mr. Fuertes, what is it you are using?

The Witness: These are notes dictated by me from my original notes of these trips, in typewritten form.

Cross-examination by Mr. Riker:

Q. Do they contain any matter not in the original notes?

A. A good part of it was dictated direct, as soon as I came back from the trip, without any notes, except memory.

Q. Where are the original notes?

A. I have none any more, whatever they were, on slips of paper, this was the record.

Q. When did you make this record?

A. These, as they are compiled here, were copied from the record made immediately after the trips were made.

Q. When did you make this record?

A. Possibly a month or six weeks ago, I do not remember exactly.

Q. Did you have the original memoranda at that time?

A. Not the original notes. I had the original dictation.

Q. Where are the original dictations?

A. They are in my office.

Q. Is this a copy of them?

A. This is a copy of them; yes, sir.

Q. Verbatim?

A. Verbatim. I can produce them for you if you wish. These are just copied from them.

Mr. Riker: All right.

Direct examination by Mr. O'Sullivan (resumed):

Q. Proceed.

A. On August 2, 1910, Commissioners Soper, Parsons, Williams and I made an inspection of Manhattan and Brooklyn waterfronts of the East River, and the waterfront along the Borough of the Bronx, as far east as City Island. The object of this trip on the tug "Edmund Moran" was to enable the commissioners to inspect, at low tide, the Manhattan and Brooklyn waterfronts of the East River, and the waterfront along the Borough of the Bronx, as far east as City Island. There was also present on this trip a representative of the New York Herald.

The conditions along the East River from the Battery to about 116th Street were similar to those which have been observed

2502 frequently on former trips. The tide was falling and the current of the East River running strongly southward while

the party progressed up the river. The sewage discharged from the various sewers, particularly from those at Oliver Street, 14th Street, 106th and 110th Streets, extended out diagonally into the river in broad streams bearing copious evidence of fresh sewage. Several free floating bathing establishments along the river, notably those at Corlear's Hook and below 110th Street were in the direct line of the floating sewage, and the water in the baths was undoubtedly heavily polluted therewith. In the neighborhood of the Queensborough Bridge, on the Manhattan side, numerous groups of boys and men congregated along the shores to enjoy bathing in the water. At one place several boys were observed taking a shower bath in sewage falling from the mouth of a sewer.

The most intense pollution was between the shores of Manhattan and Ward's Island; here, as during former inspections, the waters of the river were discolored with sewage from bank to bank.

Evidences of New York's sewage and refuse were apparent in the harbor waters, in the river water and in the waters of Long Island Sound at almost every point traversed by the tug, even as far east as City Island.

A study of the depths of the water in the various bays, such as East Chester, West Chester and Flushing Bays indicating some of the difficulties to be contended with in finding proper points for discharging sewage from the Boroughs of the Bronx and Queens. In most of these bays the water, at low tide, is not over ten feet deep, while the areas of the bay are in some instances several square miles in extent. The main channel of the East River through the westerly end of Long Island Sound is comparatively narrow and tortuous. The surface appearance of this part of Long Island Sound gives the impression that a vast quantity of water lies therein, whereas the waters between Hell Gate and Throggs Neck, with the ex-
2503 ception of those in the main channel are actually very shallow. On the return trip, for instance, the Moran grounded in the mud about one-quarter of a mile from the ferry pier, near the entrance to Flushing Bay.

Returning from City Island, the party passed to the east of Riker's Island. Evidences of decomposed sewage solids were present in the water and in the mud stirred up from the bottom of the harbor by the propellor of the tug where the water was shallow and the escaping odors were strongly those of sulphuretted hydrogen.

The return trip south from Hell Gate was made along the Brooklyn Shore. As usual, the points of most intense pollution were in the vicinity of the big sewers of Long Island City, the mouth of Newtown Creek, the Wallabout Canal, the Williamsburg Bridge and some of the large sewers near the stone working plants, refineries and market places.

Numerous photographs were taken to show the character of the waters and adjacent lands and properties.

Q. Now, that you have described your tours of inspection of Manhattan waterfront, did you at any time conduct a tour of inspection of Newark Bay and the Passaic River, and if so state with what results?

Mr. Riker: The question is objected to as calling for an answer that is immaterial and irrelevant to this inquiry and the issue in this suit.

The Commissioner: Note the objection of counsel for defendants.

A. On August 22, 1910, Commissioner Soper and I made an inspection on the tug "H. B. Moore" of Newark Bay and the Passaic River. The tug left from Pier "A" North River, passing through the Upper Bay, past Robbins Reef Light, to the Kill van Kull and thence up into Newark Bay. The waters of Newark Bay are so shallow that the tug was obliged to keep in the navigable channel for fear of being grounded, and the commissioners were, therefore unable to observe closely the character and appearance of the water along the west bank of the bay. In general, after passing
2504 through the drawbridge of the Central Railroad of New Jersey, the waters appeared to be somewhat more cloudy, and of a slightly different color, than the waters of the Upper New York Bay. Evidences of sewage pollution were visible throughout the entire trip, these evidences becoming more and more pronounced and offensive as the tug advanced up stream.

Ebb tide had set in and the current was running out quite strongly. In the absence of a navigation chart, it was not practicable to observe exactly the location of the outfall sewer from the pumping station at Newark, which has a capacity of about 30,000,000 gallons per day. The sewer discharges into the bay near the mouth of Bound Creek, about a mile and a half southwest of Passaic Light. There was a decided and pronounced sleek on the waters along the western side of the bay from the Passaic Light to the Central Railroad of New Jersey Bridge.

The wind was blowing strongly from the east and south during the entire trip, and the smooth water along the western side of the bay could have been due only to grease on the surface of the water, as the balance of the area of the bay was whipped into waves and ripples by the wind. The area covered by this apparent sleek might have been from ¼ to ½ mile in width, and possibly 4 to 5 miles in length.

After passing the Passaic Light, the Lehigh Valley Railroad Bridge and the upper Central Railroad of New Jersey bridge, the tug entered the Passaic River proper just above where the Hackensack River empties into the head of Newark Bay. The Passaic from this point to the site of the old Newark waterworks, in Belleville, north of Newark, was intensely polluted, the odors of sulphuretted hydrogen, gas tar and other pungent smells being very strong. Both banks of the river are lined with phosphate works, glue works, chemical works of various kinds, plaster works, stone sawing works, garbage dumps, elevators and other establishments, contributing by their sewage and by the odors of their products to the already unsavory atmosphere lying over the river. For the most part of the course the water in the river was black, covered with a skim of
2505 oil, grease and floating litter and practically throughout its whole length bubbles of gas rose up from the bottom to burst at the surface.

The effect of the escaping sulphuretted hydrogen was visible on every hand, in paint originally white turned to a leaden gray on boats and buildings near the water.

At the mouth of each large sewer in Newark, the muddy water from the streets and the grayish sewage made a strong contrast in color where flowing into the back waters of the Passaic.

Going up stream from Newark Bay, the first large sewer outlet was at Polk Street; this sewer is 7x8 feet in section.

The next sewer was under the Delaware, Lackawanna and Western Railroad Bridge at the city dock. The outlet is 5′ 6″x6′ 6″ in section.

The next large sewer is the Millbrook sewer at Carlisle Place. There are two here 6′ 9″x6′ 3″ sewers.

The last large sewer outlet which was passed was that of the Montclair-Bloomfield joint sewer. The diameter is 48 inches. The discharge is said to be about 10,000,000 gallons per day. Close to it is the Verona Street sewer with a diameter of 5′ 3″x6′.

A short distance below the bridge on the Greenwood Lake Branch of the Erie Railroad several boys were observed dressing on the banks of the Passaic after having been in swimming.

The drainage from the immense piles of refuse and garbage dumped at Harrison, across the river from Newark, must add considerably to the burden of organic matter discharged into the Passaic just before it reaches the head of Newark Bay.

Q. Did you conduct at any time a tour of inspection with a view of determining and observing what the conditions governing the disposal of sewage from the territories adjacent to and draining into Jamaica Bay were and if so state with what results?

A. On October 3, 1910, Commissioners Soper, Parsons, Sooysmith, Williams and I made an inspection of the conditions governing the disposal of sewage from the territories adjacent to and draining into Jamaica Bay. The Commissioners met by appointment at the club house of the Jamaica Bay Yacht Club at 10:45 A.
M., Monday, October 3, 1910. Upon arrival at the club house,
2506 word was received from the commission's launch that an accident in Gravesend Bay had disabled the propeller of the launch, and that its arrival would be delayed somewhat thereby. In view of this delay, Mr. Stillings, a member of the yacht club tendered the commission the use of the gasoline launch belonging to the club. The commission, therefore, began the inspection in this launch, leaving word for the commission's launch to follow as rapidly as practicable.

The commission first proceeded up the main channel from Holland Station past Arverne, passing under the railway bridge and proceeding up past Rockaway to the head of the bay.

Attention was called to the large number of new houses and other buildings that have been recently erected along this shore of Jamaica Bay and to the discharge of sewage into the waters at numerous places. The large areas covered by the oyster beds were noted by the commissioners and upwards of thirty boats were seen at work dredging oysters from the deposits along this main

channel. On the return from the head of the bay, the commission met the Quadrant II., the power boat which the commission had employed for the trip, but the boat was not available for the commission's use owing to the jamming of the clutch so that it was impossible to reverse the engine; this accident had occurred at the time the propeller blade was damaged. The commission, therefore, continued its inspection for the time being in the gasoline launch of the Jamaica Bay Yacht Club, passing up into the harbor of Rockaway and Inwood nearly to the point where the effluent from the Rockaway sewage disposal plant discharges. The water in this channel did not appear to be visibly polluted with sewage, excepting such evidenec as was presented by the appearance of sleek on the surface of the water. The waters were not foul nor ill-smelling, although showing the characteristic turbidity and color of the shallow waters in Jamaica Bay.

After the return to the Jamaica Bay Yacht Club, the use of a sloop, with auxiliary power, was arranged for by the owner of the Quadrant II., this sloop being the property of one of the members of the Jamaica Bay Yacht Club. The inspection was con-
2507 tinued in this sloop, the "Damascus," the party following along the beach to near the Rockaway Inlet and thence past Barren Island to Canarsie. During this trip a concrete idea was formed of the large extent of territory draining to these waters and of the apparent denseness of the population thereon. It was noted that with the exception of comparatively narrow channels running between the different islands in Jamaica Bay practically the entire expanse of water had at low tide a depth of less than 3 feet. The total water surface of the bay is estimated to be nearly 20 square miles and the extreme shallowness of the water over this large area greatly increases the difficulties attendant upon the satisfactory disposal of sewage from the districts draining thereto.

The pollution of the waters in the neighborhood of Canarsie was observed and in this locality as in practically all others traversed by the commission's launch, oysters were being dredged for the market. After leaving Canarsie, the commission passed out through the east channel of the Rockaway Inlet to a point about a mile off shore, returning through the west channel of Rockaway Inlet and entering Sheepshead Bay, where the members disembarked and returned to the city by rail. The most striking impressions formed from the inspection were the large and rapidly increasing development of residential districts around the periphery of the bay, the imperative necessity for a comprehensive scheme to to care of the sewage from this rapidly growing district and the difficulties that would attend the outlining of such a scheme owing to the large area covered by the shallow waters of the bay.

Q. Did you conduct a tour of inspection of the East and Harlem Rivers at any time, and if so, state with what results?

A. On October 17, 1910, Commissioners Soper, Parsons, Sooysmith, Williams and I made an inspection on the launch Quadrant II., of the East and Harlem Rivers. The launch started from the Battery at about half past one P. M., passing up the East River to

Pier 26, where the Oliver Street Sewer discharges, crossing thence over to the Brooklyn Navy yard, entering Wallabout Canal which was traversed to its head, and thence passing up the
2508 East River and through the Harlem River to the crossing of the subway where the party disembarked.

The tide was low, or nearly low, during the entire trip, and the conditions very favorable for observing the travel of sewage out into the main channels of the streams. Wallabout Canal was in a filthy condition, both as to appearance and odor, the sleek from this discharge showing a visible effect for a great distance out into the river. The East River from the lower end of Ward's Island to the mouth of the Harlem was, as on previous inspections, a field of sewage from bank to bank, the appearance and odor being unmistakable and strong. Evidences of fresh sewage were seen throughout the whole length of the Harlem River and the stench from the decomposing organic matter on the flats along both the banks of the river was very disagreeable and distinctly different from the odor that comes from the ordinary salt marsh lands alternately flooded and uncovered.

Q. Mr. Fuertes, you testified earlier of your experience in other harbors and of your inspections in other harbor waters. How do you find the harbor waters of New York compare in appearance with respect to sewage pollution with those other harbors that you mentioned earlier in your testimony?

A. Unquestionably the waters of New York Harbor show more intense pollution with sewage and municipal wastes than the waters of any other harbor that I have personally inspected.

Q. What reports have the Metropolitan Sewage Commission published since 1908 showing results?

A. The published reports of the commission have been as follows:

Digest of data collected before the year 1908, Relating to the Sanitary Condition of New York Harbor—1909.

Preliminary Report. Metropolitan Sewage Commission of New York—March 1, 1910.

Sewerage and Sewage Disposal in the Metropolitan District of New York and New Jersey—April 30, 1910.

2509 Report on the discharge of Sewage from the proposed Passaic Valley Sewer of New Jersey—May 23, 1910.

Report on the proposed Discharge of Sewage from the Bronx Valley Sewer—July 25, 1910.

Preliminary Reports—

I. Study of the Collection of the Sewage of New York City to a Central Point for Disposal—September, 1911.

II. Description of the Four Principal Drainage Divisions in that part of the Metropolitan Sewage District which lies in New York State—November, 1911.

III. Study of the Collection and Disposal of the Sewage of the Jamaica Bay Division—November, 1911.

Q. Have you in the course of your professional work made any examinations and reports on questions of sewerage and sewage

disposal of any of the cities or towns in the Passaic Valley Sewerage District, or in the New Jersey Metropolitan District, and if you have, can you produce copies of such reports?

A. I have reported upon the sewage purification of Orange, Montclair and East Orange, in the Passaic Valley Sewage District, and herewith produce a copy of my report to these cities. I have also reported on the sewage disposal of Hackensack and am now preparing reports on the sewage disposal of Hoboken, N. J., and on the disposal of the sewage of Cranford and other towns in the Rahway Valley. Here is a carbon copy of the report and a printed copy.

Q. This printed report on the sewage disposal of Orange, Montclair and East Orange, dated October 14, 1911, was prepared by whom?

A. Prepared by myself.

Q. Did you read the proof sheets of the printed report and compare it with the original typewritten matter that you prepared?

A. I read the printed report and compared it with the typewritten matter

Q. And found it how?

A. Found it correct, found it to be a correct copy.

Q. And do you now produce the second or first carbon impression of the original report made at the time, and which was furnished to the authorities of these municipalities?

2510 A. I do. That is the carbon copy.

Mr. O'Sullivan: I offer this printed report in evidence and ask that it be marked Complainant's Exhibit No. 137 in evidence.

Cross-examination by Mr. Riker:

Q. Mr. Fuertes, you know that Orange, Montclair and East Orange have joined in the contract for the construction of this proposed sewer, do you not?

A. I do not know of my own knowledge anything about it.

Q. You have heard so?

A. Yes, I have heard so.

Q. And this is a report prepared by you for the purpose of establishing independent sewage disposal plants, is it not?

A. It was, yes.

Mr. Riker: The offer is objected to on the ground that it is not material or relevant in this cause and it does not appear that these municipalities have any connection with the present proposed outlet sewer of the Passaic Valley Sewerage Commissioners. It is also objected to on the ground that in so far as it contains evidential matters that it does not contain any matters of fact that are properly proved in his cause.

The Commissioner: Note the objection of counsel for defendants. Received and marked Complainants' Exhibit No. 137.

Direct examination by Mr. O'Sullivan (resumed):

Q. As a result of the studies prosecuted in making the report to Orange, Montclair and East Orange, did you find that it was feasible for the three cities, Orange, Montclair and East Orange, to establish purification works independently of the Passaic Valley Sewerage Commission, and at a cost for construction and operation that would be less than the estimated cost to these cities of joining the Passaic Valley Sewerage Commission project?

Mr. Riker: I object to it on the ground that it is immaterial and irrelevant. The matters as to which the witness is asked to testify have no relation to the issues of this cause.

The Commissioner: Note the objection of counsel for defendants.

A. I did. I here quote from the said report my conclusions in regard to this matter, beginning on page 40.

2511 Q. That is, Complainants' Exhibit No. 137?

A. Complainants' Exhibit No. 137.

"For the purpose of showing the relative costs of constructing and operating the plant recommended with the costs of the three cities under the plan proposed by the Passaic Valley Sewerage Commission in their report of 1908, I have arranged from the data given in that report the costs of construction as given; and the annual costs of operation, with interest and sinking fund at 6½%, and the other operating costs in the proportion of the use these towns would make of the sewer (as stated in the report) to the total capacity of the sewer, or in the ratio of 37 to 360. This gives a total cost of $124,567 for interest and sinking fund and $29,000 for the other items, or a total by 1940 of $153,567.

"On these bases the costs of construction of works sufficient for the population to be expected by 1940 would be as follows:

Estimated Construction Costs to Orange, Montclair and East Orange of Joining in the Passaic Valley Sewer Project.

Cities.	Orange.	Montclair.	East Orange.	Total.
Costs	$418,890	$600,649	$896,871	$1,916,410

Estimated Annual Costs to Orange, Montclair, and East Orange of Joining in the Passaic Valley Sewer Project.

Cities.	Orange.	Montclair.	East Orange.	Total.
Fixed Charges	$39,363	$39,861	$45,343	$124,567
Other Items	9,164	9,280	10,556	29,000
	$48,527	$49,141	$55,899	$153,567

2512 "A comparison of these figures with those for the plan recommended herein shows that it will cost the three cities nearly $670,000 more to join in the Passaic Valley Sewer project than to build a local disposal plant and nearly $50,000 per year

more to meet the necessary operating expenses of the Passaic Valley Sewer than of the plant recommended."

Q. Have you made any study of the relative capacities of Newark Bay and of the Upper New York Bay to receive the sewage of the towns on their respective drainage areas?

A. I have and here summarize briefly the results:

The average discharge from Newark Bay during an ebb tide through Kill van Kull has been found, as shown by Mr. Parsons, to be 1,644,000,000 cubic feet, or 3,288,200,000 cubic feet per lunar day.

The total average discharge passing through the Narrows on ebb tides has been found similarly to be 12,041,200,000 cubic feet per tide, or 24,082,400,000 cubic feet per lunar day. This amount includes, of course, the quantity that is discharged from Newark Bay through Kill van Kull, so that the net discharge from the Upper Bay, exclusive of that from Newark Bay would be the difference, or 20,794,200,000 cubic feet per lunar day. Since, as has been found by the U. S. C. & G. Survey about 84% of the discharge of Newark Bay passes through the Kill van Kull, and 16% through the Arthur Kill, the total average discharge from Newark Bay on ebb tides may be taken as about 1,952,400,000 cubic feet per tide, or 3,904, 800,000 cubic feet per lunar day.

The populations naturally tributary to Newark Bay as shown by the census of 1910, and as estimated for 1940, are as follows:

2513 TABLE I.

Populations on Watershed of Newark Bay, Within the Metropolitan District.

Districts.	1910.	1940.
Passaic Valley Sewerage District.....	734,396	1,649,420
Hackensack River Valley	72,838	260,000
Other New Jersey Districts	183,458	472,240
In New York State	12,171	18,000
Totals	1,002,863	2,399,660

Cross-examination by Mr. Riker:

Q. Where did you get the figures on Table I?

A. The 1910 figures from the United States Census, distributed among the different territories. The 1940 figures are estimates.

Q. Who made up the table from the census?

A. That I could not tell you.

Q. You did not do it?

A. No, I did not do it myself.

Q. And is the same true of your next table, No. II?

A. The same is true of Table No. II.

Mr. Riker: I object to the tables on the ground that they are not properly proved.

The Commissioner: Note the objection of counsel for defendants.

Direct examination by Mr. O'Sullivan (resumed):

Q. Did you take these columns for the 1910 figures set forth there from the official reports of the United States Census?

A. Personally I did not.

Q. Proceed with the table, Mr. Fuertes.

Mr. Riker: I object to the testimony as to the populations
2514 of 1910 in the districts indicated by the witness, on the ground that he states he has no personal knowledge of the correctness of the figures.

The Commissioner: Note the objection of counsel for defendants.

A. Table No. II is as follows:

Territory tributary to the Upper Bay of New York Harbor:

TABLE 2.

Populations on Watershed of Upper Bay of New York Harbor, Within the Metropolitan District.

Districts.	1910.	1960.
In the State of New Jersey	488,516	1,036,000
In New York State	4,540,961	8,331,900
Other districts in New York State	38,708	93,000
Totals	5,068,185	9,460,900

Q. Proceed, Mr. Fuertes.

A. If the Passaic Valley sewer were not to be extended to New York Harbor, but the raw sewage of the New Jersey communities were all to be drained to Newark Bay the relative flows out of Newark Bay and the Upper New York Bay would bear the ratios to the respective populations tributary thereto, as given in Table 3.

Mr. Riker: Table 3 was compiled from what?

The witness: From the flows given in my testimony here as to the populations in these two tables that I have just given.

Mr. Riker: I object to the witness testifying on the basis of figures of which he says he has no personal knowledge that they are correct, he not even having made up the compilations from the census reports.

2515 The Commissioner: Note the objection of counsel for defendants.

Q. Proceed with Table No. 3.

A. Table No. 3 is as follows:

TABLE 3.

Tidal Flow of Newark Bay and Upper New York Bay per 1,000 People per Lunar Day, Passaic Valley Sewer to Discharge Crude Sewage Into Newark Bay.

	Newark Bay.			Upper New York Bay.		
		Cubic feet of tidal outflow per lunar day (89,428 seconds).			Cubic feet of tidal outflow per lunar day (89,428 seconds).	
Year.	Population.	Total flow.	Flow per 1,000 people.	Population.	Total flow.	Flow per 1,000 people.
1910..	1,092,883	3,904,800,000	3,804,000	5,068,145	20,794,200,000	4,103,000
1940..	2,390,000	3,904,800,000	1,627,000	9,460,000	20,794,200,000	2,198,000

2517 Q. Now, assuming that the Passaic Valley Sewer were to be built, have you compiled any table to show what the diverting of that sewage of all the points in that Passaic Valley watershed to New York Harbor would result in?

A. I have. In case the Passaic Valley sewer were to be built, diverting the raw sewage of all the points in this valley to New York Harbor, the figures would be as given in Table 4.

Cross-examination by Mr. Riker:

Q. Now, Mr. Fuertes, how was this table made up, from what data?

A. In the same way, from this same data.

Q. And does it or does it not contain estimates upon the basis of the territory included in the Hackensack Valley?

A. No, that is so far as the effect upon New York Harbor is concerned, it does not. It just takes the sewage of the Passaic Valley into New York Harbor, and allows the balance of the New Jersey territory to drain into Newark Bay.

Q. What municipalities does it contemplate as discharging into New York Bay?

A. All the towns that are in the Passaic Valley District. That population is taken from the populations given in the report of the Passaic Valley Sewerage Commissioners.

Q. Do you know that?

A. Yes, I think I checked that over.

Q. Where did you get the municipalities on which you based your estimate?

A. They came right from that report.

Q. What report is that?

A. The report of the Passaic District, the Passaic Valley Sewerage report.

Q. What report?

A. The date I do not remember.

Q. Did it include Orange, East Orange and Montclair?

A. Yes, I think it did.

Q. Did it include several towns and municipalities in Bergen County?

A. I could not say without getting my original figures and looking it up.

Q. Do you know as a matter of fact whether it included municipalities and territory not described to be within the Passaic
2518 Valley Sewerage District as defined by legislative act?

A. That I do not know.

Q. How many of these municipalities have entered into the construction of this sewer?

A. That I do not know.

Mr. Riker: I object to the reading of this table into the record on the ground it is immaterial and irrelevant, because it does not appear that it was confined to the municipalities which are concerned in the proposed Passaic Valley Sewer.

The Commissioner: Note the objection of counsel for defendants.

Direct examination by Mr. O'Sullivan (resumed):

Q. Proceed, state the contents of that table.

A. Table No. 4 is as follows:

2519

TABLE 4.

Tidal Flow Out of Newark Bay and Upper New York Bay per 1,000 People per Lunar Day, if Passaic Valley Sewer Discharges Crude Sewage Into Upper New York Bay.

	Newark Bay.			Upper New York Bay.		
		Cubic feet of tidal outflow per 24 lunar hours (89,428 seconds).			Cubic feet of tidal outflow per 24 lunar hours (89,428 seconds).	
Year.	Population.	Total flow.	Flow per 1,000 people.	Population.	Total flow.	Flow per 1,000 people.
1910..	268,667	3,904,800,000	14,544,000	5,892,581	20,794,200,000	3,583,000
1940..	750,240	3,904,800,000	5,205,000	11,110,329	20,794,200,000	1,871,000

2520 Q. Now, relative to Table No. 5, Mr. Fuertes.

A. If instead of building the Passaic Valley Sewer, the sewage in the towns of the Passaic Valley District were to be treated on the Newark Meadows to remove about 50% of the organic matter, including the suspended particles, and the effluent from the works were to be discharged into Newark Bay without further treatment, the effluent would have only about half the strength of the raw sewage and under these conditions the dilution ratio would stand as given in Table 5.

Mr. Riker: This table you are now about to testify to, is it based upon the same data that the last one was?

The witness: All the same data used here, all the same.

Mr. Riker: The reading of these figures into the record is objected to on the same ground and also on the ground that the figures are directed toward a hypothetical condition which is not in contemplation and as to which the issues in this cause have no relation, and it is therefore immaterial and irrelevant.

The Commissioner: Note the objection of counsel for defendants.

Q. State the contents of that table No. 5?

2521 TABLE 5.

Tidal Flow Out of Newark Bay and Upper New York Bay per 1,000 People per Lunar Day, if Passaic Valley Sewage Were to Be Partially Purified, by Removal of 50% of Organic Matter and Effluent Discharged Into Newark Bay.

	Newark Bay.			Upper New York Bay.		
		Cubic feet of tidal outflow per lunar day (89,428 seconds).			Cubic feet of tidal outflow per lunar day (89,428 seconds).	
Year.	Population.†	Total flow.	Flow per 1,000 people.	Population.	Total flow.	Flow per 1,000 people.
1920..	501,431	3,904,800,000	7,788,000	5,068,185	20,794,200,000	4,103,000
1940..	1,196,830	3,904,800,000	3,254,000	9,460,900	20,794,200,000	2,198,000

† The population figures here given are half the actual populations and are so given because under the treatment proposed the sewage would have only half the strength of the normal sewage, and the effluent discharged into the harbor would be the equivalent, in polluting properties, of the crude sewage of half the actual population.

2522 Q. Now, Mr. Fuertes, will you discuss the statements in Tables 3, 4 and 5?

Mr. Riker: The question is objected to on the ground that the figures in the table referred to are not proved so as to be admissable as evidence in this cause and the discussion of these tables is therefore irrelevant and immaterial.

The Commissioner: Note the objection of counsel for defendants.

Mr. O'Sullivan: I will withdraw my question.

Q. Mr. Fuertes, what do the statements as set forth in tabular form in Tables 3, 4 and 5 show?

Mr. Riker: The same objection as to the question that was withdrawn.

A. These statements show, Table 3, that Newark Bay could now take all the sewage of its tributary districts, in a crude state, and dispose of it by dilution as effectively as Upper New York Bay will be able to dispose of its tributary sewage about fifteen years from now, while, Table 5, if the New Jersey sewage were to be treated to remove the solids and suspended matters Newark Bay would be better able to dispose of the clarified sewage 25 years from now than the Upper Bay will be able to dispose of its tributary sewage. They, however, also, Tables 4 and 5, show that steps must be taken soon to prepare for the purification of the sewage of part of the present and much of the future territory in New York State, as it takes many years to make provisions for such works, and many more to build them and place them in operation.

They also show, Table 4, that if the Passaic Valley Sewer were to be built the ratio of outflow to population in the Upper Bay would be about the same, Table 3, as in Newark Bay for the crude sewage from its tributary area only which would then discharge therein, whereas, Table 5 if the New Jersey sewage is treated and discharged into Newark Bay then both at present and by 1940 the ratio would be considerably better in the Newark Bay than the Upper Bay receiving crude sewage.

Recapitulating and reducing these flows to cubic feet per second per thousand people, instead of cubic feet per lunar day, assuming the rate of flow to be constant instead of harmonic, the results would be as given in Table 6.

Mr. Riker: This table No. 6 that you mention is based on the same data?

2523 The Witness: This table is a compilation from these tables here.

Mr. Riker: Based on the same data?

The Witness: The basic data is the same, yes.

Mr. Riker: The reading of this table into the record is objected to on the same grounds as urged to the last two tables.

Q. State the contents of that Table No. 6?

TABLE 6.

Estimated Relative Tidal Outflow in Cubic Feet per second per 1,000 People from Newark Bay and Upper New York Bay, With Different Plans for Disposing of the Sewage from the Passaic Valley District. ‡

	Year.	Average uniform rate of outflow in cubic feet per second per 1,000 people contributing sewage from— Newark Bay.		Upper New York Bay.	
New Jersey communities discharging raw sewage into Newark Bay.	1910....	43	5.37‡	46	5.75‡
	1940....	18	2.25‡	24	3.00‡
Passaic Valley sewage discharged into Upper New York Bay.	1910....	162	20.25‡	40	5.00‡
	1940....	58	7.25‡	21	2.63‡
Sewage of New Jersey communities treated and discharged into Newark Bay.	1910....	87	10.89‡	46	5.75‡
	1940....	36	4.50‡	24	3.00‡

‡ NOTE.—Since the tides flow in and out of the harbor with a varying speed and since the sewage is discharged from the sewers continuously, but at a varying rate, it is evident that some parts of the waters will be charged more heavily with sewage than others; for instance, at the turning of the tides the harbor waters will be practically stationary, and the sewage will be discharged into it at its natural rate of flow, while when the tide is running at its maximum speed the sewage will be scattered through a large volume of water. It is also evident that it will be practically impossible to mix all of the sewage uniformly through all of the tidal water as it flows out. Just what degree of commingling it would be practicable to secure would depend on many varying conditions. But for the sake of illustration the following assumptions may serve to show what might reasonably occur with frequency.

1. At times the tidal currents will have velocities not more than one-half the average.

2. At times the rate of sewage discharge will be double the average rate.

3. It would be unreasonable to expect to secure a greater efficiency in dispersion than 50%, considering the difficulty of mixing the sewage through the entire tidal volume.

These three assumptions alone show that at times the concentration of the sewage in the tidal volume will be at least 8 times the average. There will be many occasions, when the range of tide is small, due to the winds and other natural phenomena, when the concentration will be much greater than this. But assuming, however, that some parts of the outflowing waters would carry at least eight times as heavy a burden of sewage as under average conditions the figures marked with an indicator, #, in the above table would represent the practical dilutions corresponding to these conditions, with the possibility of either better or less favorable results.

I am not cognizant of any definite data on the relative amount of sewage pollution that sea water will stand without creating a nuisance. General considerations would indicate that sea water will not stand as much pollution relatively as land water since at equal temperatures it will hold less dissolved oxygen, and also on account of its well-known property of hastening the subsidence of suspended sewage matters by which a greater amount of deposition will take place in a given time in sea water than in equally polluted fresh water. We have, however, pretty well established data regarding the effect of the pollution of fresh water by sewage and the limits of the pollution between which nuisances are or are not likely to occur. This information is summed up in very convenient form for reference in a table prepared to illustrate an article by Mr. E. P. Stearns, published in the 1890 report of the Massachusetts State Board of Health, on the pollution of streams, and printed on pages 785 to 793 of that report. The table referred to is on page 789. Briefly summarizing the results of this table it may be stated that when the flow of fresh water is less than 2 cubic feet per second per thousand people a nuisance is sure to result. While if it is greater than 7 cubic feet per second per thousand people "the pollution is so small as to be clearly admissable from the standpoint of the offensiveness of the water." Between 2½ and 7 cubic feet per second per thousand people there may be doubt as to whether a nuisance wil result or not, depending upon conditions. Among these varying conditions would be the rate of flow of the water, the opportunities afforded for the subsidence of the suspended matters on the bottom of the stream and the nature and amounts of manufacturing wastes which are discharged into the stream.

Without attempting to draw fine lines to differentiate between permissable and non-permissable pollution or to attempt to predict the effect of the less favorable conditions existing in sea water than in fresh land water it will be seen by reference to Table 6 that under all the hypotheses above stated the waters of Upper New York Bay lie within the range of the danger of nuisance at the present time,

approach- very closely to the limit of certain nuisance by 19140, even if the Passaic Valley sewage is kept out of the harbor, and much more closely to it if the Passaic Valley sewage is discharged into New York Bay, while if the Passaic Valley sewage is discharged into New York Harbor then both at the present time and by 1940 the waters of Newark Bay will be entirely free from the danger of possible nuisance until 1940. If, on the other hand, the sewage of the New Jersey communities is treated, as suggested, and then
2526 discharged into Newark Bay, the waters of that Bay will be able to take care of the effluent from the New Jersey communities until 1940 with much less risk of nuisance in Newark Bay than will obtain in New York Harbor even if the Passaic Valley sewage is all diverted from New York Bay.

This discussion points out clearly that the Passaic Valley proposition is an effective means of protecting Newark Bay from pollution at the expense of increasing the pollution of New York Harbor, and that relatively simple treatment of the New Jersey sewage would permit of its discharge into Newark Bay without taxing the assimilative capacity of that body of water for at least the next twenty years, and that after it shall have become apparent that further treatment is necessary, means can be adopted for oxidizing the organic matter in the effluent from the settling basins to a non-putrescible condition at relatively small cost.

The accompanying digram shows the data in Table 6 arranged to exhibit graphically how little margin the waters of New York Harbor may have above a condition of general offensiveness. They lie, both in 1910 and 1940, in the class where nuisances may or may not result, depending on local conditions, and where unfavorable tides, winds or temperatures may temporarily change an inoffensive harbor to an offensive condition. In other words, the harbor is now polluted more than it should be. These deductions are borne out by the inspections as well as by the dissolved oxygen results, which show depletion, ranging from time to time and in amounts significant of serious consequences.

Q. What diagrams did you just refer to, Mr. Fuertes?

(Witness produces diagrams.)

Q. Who prepared this diagram?

A. I did.

Q. And what does it purport to show?

A. There are three diagrams here, the one on the left shows the estimated relative pollution of Newark Bay and Upper New York Bay if the New Jersey sewage from the territory tributary to Newark Bay, including the Passaic Valley sewage, is discharged
2527 crude into Newark Bay. The middle diagram shows the conditions of pollution in Newark Bay and Upper New York Bay if the Passaic Valley sewage is discharged into Upper New York Bay and the third diagram shows the pollution of Newark and Upper New York Bays if the New Jersey sewage were discharged partially purified into Newark Bay. These are tinted respectively blue, red and brown. The blue area represents conditions of tidal

flow, such as that the flow per thousand people contributing sewage would be more than 7 cubic feet per second. The red area shows the tidal flow per thousand people when the tidal flow would range between 2½ and 7 cubic feet, and the brown area shows the tidal flow per thousand people when the pollution is less than 2½ cubic feet per second. The diagram for Newark Bay is colored green, and for Upper New York Bay yellow in each case, and they show by the length of the ordinates from the bottom line the flow per thousand of population from 1910 to 1940 in each case. The inclined line joining the two end points in each diagram indicates the rate of growth of population of the town between those years.

Mr. Riker: One moment. If the diagram is to be used it ought to be offered.

Mr. O'Sullivan: I am asking him to describe what it is.

Mr. Riker: He is testifying to the contents of this diagram.

Mr. O'Sullivan: I offer the diagram described by this witness, testified to by this witness as having been prepared by him, I offer it in evidence and ask that it be marked Complainants' Exhibit No. 138.

Cross-examination by Mr. Riker:

Q. Mr. Fuertes, who prepared this diagram?

A. I made the original diagrams; these are prints prepared in my office.

Q. You compared them with the original?

A. Yes.

Q. And on what data was the original diagram prepared?

A. They are prepared from the data given in Table No. 6.

Q. And Table No. 6 was based on data given in some other tables?

A. Yes.

2528 Q. And this data assumed in part relates to census figures of 1910, of which you have no personal knowledge?

A. Which I have not personally checked.

Q. So this data besides the census figures are involved in this diagram?

A. This diagram is just a plotting of the data given in Table No. 6. Just the figures taken from Table No. 6.

Q. A graphic representation of the contents of that table?

A. That is the idea.

Q. In that table is there anything that corresponds in figures to the area that is colored blue in this diagram?

A. No, but that is described in my testimony just following, what this area is.

Q. What is that area, if it is based on the figures; what does it represent?

A. This area represents a flow out of New York Bay and Newark Bay in excess of 7 cubic feet per second.

Q. For both Newark and New York Bays?

A. Yes.

Q. Is that arbitrary?

A. It is arbitrary, excepting that, as I explained in my testimony,

whenever the flow was more than 7 cubic feet per thousand people per second there was no likelihood of nuisance.

Q. That is a graphic representation of conditions under which you are testifying there is no danger of sewage pollution?

A. Yes. In the same way the red area is an area in which it is questionable whether there would be a nuisance or not resulting.

Q. Neutral zone?

A. It is a questionable zone. There might be or there might not be.

Q. There is no data to determine whether there would be or would not be?

A. No.

Q. And the brown area?

A. That is bad. Pretty certain to have a nuisance. If the flow falls within the brown area you would be pretty sure to have a nuisance.

Q. Now, taking the part of the diagram on the left side of the paper, the section of it which is marked Upper New York
2529 Bay and colored yellow, upon what figures is that based. What data I should say?

A. Those figures, the highest point on the left of that yellow diagram on the left, that is taken from Table No. 6, the first figure that appears on the right hand column of Table No. 6. That is 5.75.

Q. 5.75?

A. And at the right hand corner of the diagram, in Figure 3, the line was just drawn joining those two points.

Q. And upon what assumption is that figure made?

A. That is taken from Table No. 3. That is based on the tidal flow out of Upper New York Bay per thousand people discharging sewage.

Q. Upon the basis of what population?

A. The population is given in the tables. The population for 1910 by the first line, and for 1940 by the last line.

Q. Does it in any way indicate for 1940 at what points the population is estimated to be located, as far as it concerns New York State in distinction from the State of New Jersey?

A. I do not know that I understand you.

Q. You do not understand?

A. I do not understand, no.

Q. Is there anything in the estimate of the population for 1940 which locates any portion of it in New York State or any portion of it in New Jersey?

A. You mean for New York Bay?

Q. Yes.

A. These populations were divided in that way. This represents only the population of New York Bay.

Q. Part of the population on New York Bay is in New Jersey?

A. Certainly, and that portion is included in this. What discharges in there is included.

Q. Have you attempted to analyze the estimated population of

1940 on New York Bay to distinguish those of New York from those of New Jersey?

A. Personally I have not checked that over. I have not checked those figures.

Q. You do not know anything about it?

A. Not of my own knowledge. I have not checked that personally.

2530 Q. Now, the green area on that first division on the left of this diagram, that is based in the same way?

A. That is determined in the same way, in the same general way.

Q. In the same way as the yellow area?

A. Yes.

Q. And represents graphically a conclusion that you have suggested in your table, that a discharge of the crude sewage of the Passaic Valley District into Newark Bay would result in practically the same result upon the waters of that bay, as the crude sewage of the territory about Upper New York Bay upon the sewage of New York Bay?

A. That would be a trifle worse into Newark Bay.

Q. Only a trifle worse?

A. The population tributary to Upper New York Bay is both in New Jersey and New York and that bears about the same relation to the flow that the population tributary to Newark Bay does. It is larger for Newark Bay, and it would be still a little greater ratio for 1940 than it will be in New York Bay.

Q. It will be a little larger than Upper New York Bay aat the present time?

A. Yes, New York Bay is in a little better condition.

Q. Than Newark Bay if it had direct discharge into Newark Bay of the sewage from the present population in the Passaic Valley?

A. Not only that, but all the tributary New Jersey population—that includes the Hackensack River as well.

Q. On the assumption that that is to be discharged directly into Newark Bay?

A. No, the calculations are made simply on that basis to show the ratio of the two populations tributary. There is no assumption as to any special method of discharge. Simply that the crude sewage from the district would get into these waters.

Q. Under equal conditions?

A. Under equal conditions, yes. No purification in either case. Simply assuming that the sewage got in there, quality and other things being equal.

Q. And other characteristics?

A. Yes.

2531 *A*. Now, the middle diagram, Mr. Fuertes, the yellow section there representing conditions in Upper New York Bay; what is that? What data did you use for that?

A. The same as the other, putting all the sewage from the Passaic Valley District of New Jersey into New York Bay and taking out Newark Bay.

Q. And what data did you use for that?

A. The data for that, as far as Upper New York Bay is concerned, is precisely the same as in the first diagram, and for Newark Bay the population is just one-half of that given in the diagram. In other words, you have a specified computation of sewage, and you take that out, and you have the putrescible matter which would make its ratio double.

Mr. Riker: The offer of the diagram is objected to on the ground that it is only a statement of the witness, based upon data which are not within his personal knowledge and which have not been proved in this cause. A further objection on the ground that the diagram represents in that form tables which have been objected to and are therefore subject to the same objection, and also on the ground that it seeks to represent hypothetical conditions which are not a part of this case, not based upon any facts proved in this case, and that therefore, in so far as it relates to this hypothesis it is immaterial and irrelevant.

The Commissioner: Note the objection of counsel for defendants.

Received and marked Complainants' Exhibit No. 138.

Marked Complainants' Exhibit No. 138.

Adjourned to June 26, 1912, at 10.30 A. M.

[End of Volume II.]